Materials Engineering in Product Design & Manufacture

Materials & Methods

December 1953

M & M Manual No. 100 — Engineering Coppers

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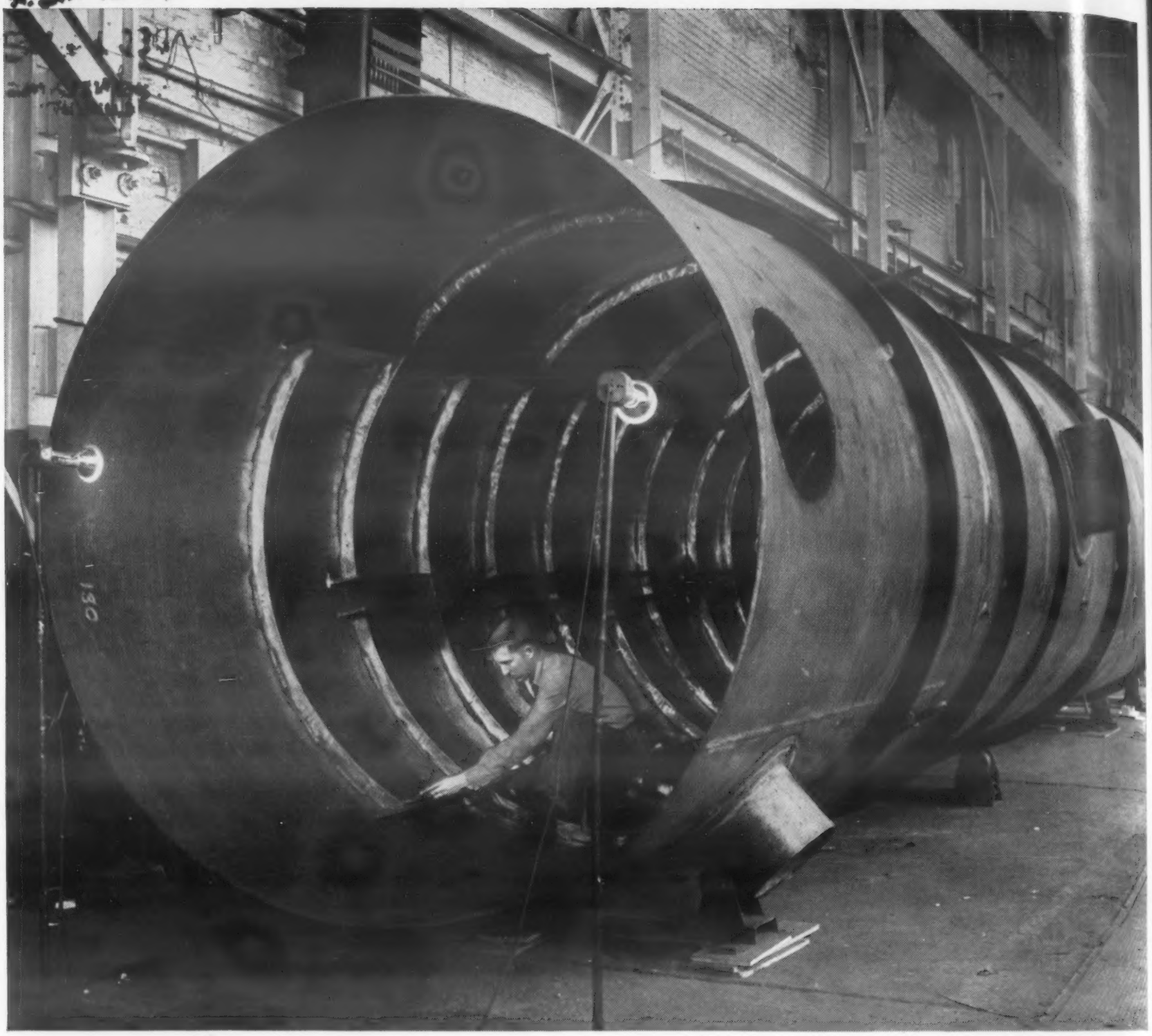

FRACTIONATING TOWER designed and fabricated by Vulcan Manufacturing Division of The Vulcan Copper & Supply Co., Cincinnati.

COPPER–select it for performance–fabricate it at low cost

This is a fractionating tower 30 feet long and 10 feet in diameter—and it's made entirely of phosphorized copper.

Copper and its alloys are logical choices for building many kinds of process vessels because their complete immunity to rust and high resistance to corrosion are important assurances of long equipment life.

And more than that, the practicability of fabricating copper with the new automatic welding methods helps keep down the costs of equipment. The many components of this tower, with metal thicknesses ranging from ¼" to ½", were rapidly assembled by the inert-gas consumable-electrode method. The welding rod was ANACONDA Copper-372*. Routine X-ray inspection showed consistent soundness of the finished welds.

In designing or specifying your process equipment, consider the unique combination of properties which only copper and copper alloys offer in such high degree. These include rapid and uniform heat transfer and ready workability, combined with good mechanical strength and resistance to fatigue.

For detailed information or for technical counsel on any form of copper or type of copper alloy, or any problem related to their use in your business, the services and experience of our Technical Department are always available. Just write to *The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.* 58122

*U.S. Patent No. 2,220,464

for copper and its alloys–consult

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Materials & Methods

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FEATURE ARTICLES

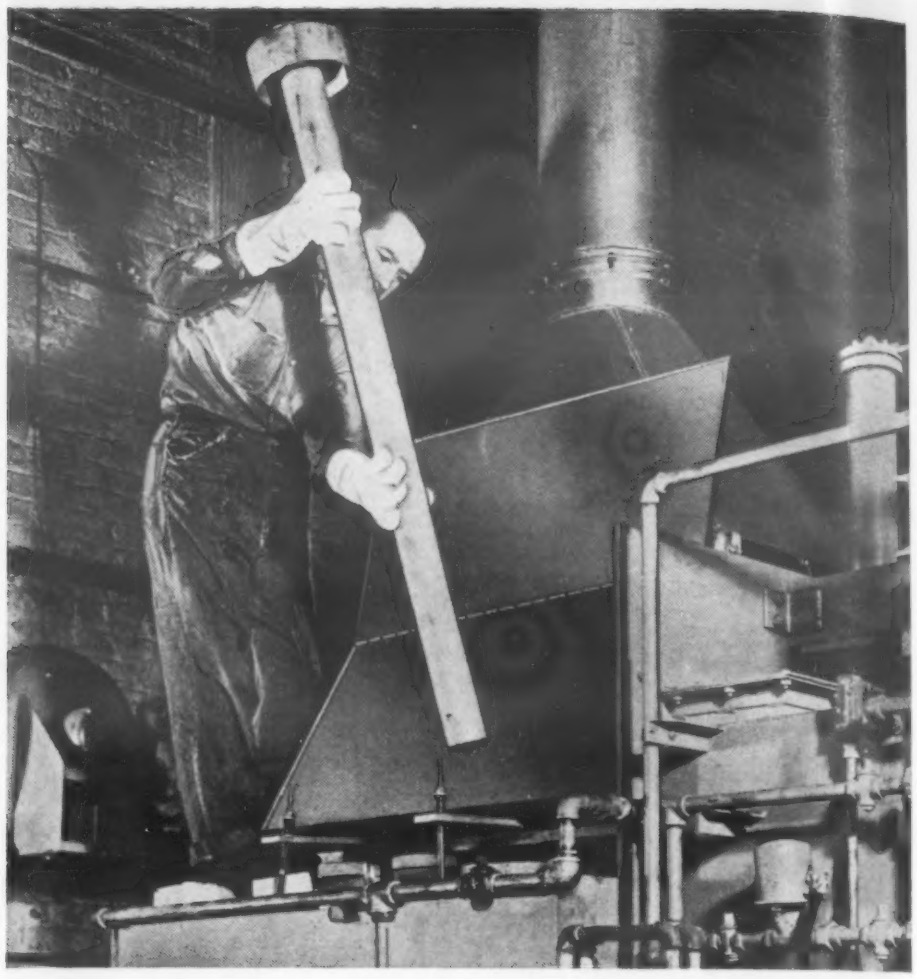
MATERIALS & METHODS MANUAL NO. 100

ENGINEERING FILE FACTS

DEPARTMENTS

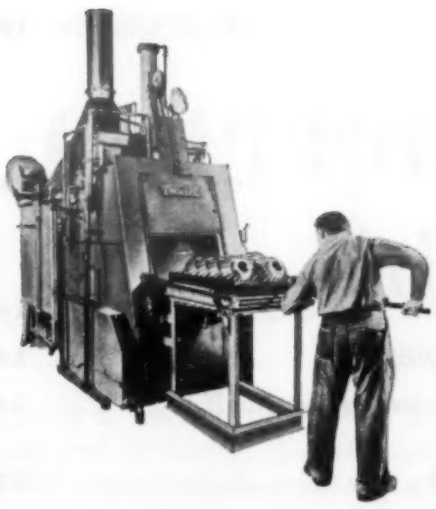
PRICE 50 CENTS A COPY. PAYABLE IN ADVANCE, ONE YEAR, $2.00; TWO YEARS, $3.00; THREE YEARS, $4.00 IN U. S., POSSESSIONS AND CANADA. IN ALL LATIN AMERICAN COUNTRIES: ONE YEAR $10.00; TWO YEARS, $16.00; THREE YEARS, $20.00. ALL OTHER COUNTRIES: ONE YEAR $15.00; TWO YEARS, $25.00; THREE YEARS, ($30.00 REMIT BY NEW YORK DRAFT.) REENTERED AS SECOND CLASS MATTER JULY 19, 1951, AT THE POST OFFICE AT NEW YORK, N. Y., UNDER THE ACT OF MARCH 3, 1879. ESTABLISHED IN 1929 AS METALS AND ALLOYS.

Inconel radiant tubes in new Lindberg multi-purpose furnace come out on top!



Time for a Change? It's no job at all to slip one of these thin-wall Inconel vertical tubes into the new Lindberg Carbonitriding Furnace. The tube collar, which forms a heat seal, is shaped from Inconel sheet and welded to the tube. These lightweight tubes transfer heat efficiently, yet give long service life because of Inconel's resistance to oxidation and many corrosive atmospheres at high temperatures.

You would hardly believe that replacing a radiant tube could be this simple — *but it is!*



In the carbonitriding furnace recently developed by the *Lindberg Engineering Company*, of Chicago, all you do is lift out the old tube and hang a new one in its place.

Inconel® tubes like the one shown above weigh only 29 pounds.

Yet they are sturdy and long-lasting. They resist oxidation and many corrosive furnace atmospheres at high temperatures. They must, for tubes really get a workout in this furnace! Lindberg designed it to handle not only carbonitriding, but hardening, carburizing, annealing and carbon restoration as well. Different furnace atmospheres are supplied by an adjustable generator.

Inconel takes all of these varying conditions in stride. It resists cracked ammonia and carbon monoxide atmospheres, and provides excellent strength throughout the entire carbonitriding temperature range. Its good strength persists at temperatures up to 2,200°F. Also, it is readily workable and can be welded by ordinary shop methods.

You can see, then, why Lindberg has standardized on Inconel tubes for their new furnace.

To learn how Inconel can serve you in troublesome high-temperature applications, write for a copy of the booklet, *Keep Operating Costs Down... When Temperatures Go Up.* It's yours on request.

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INCO

Inconel... *for long life at high temperatures*

For more information, turn to Reader Service Card, Circle No. 396

The Materials Outlook

HIGH TEMPERATURE ALUMINUM

A new aluminum casting alloy now under development is expected to extend potential elevated temperature applications for the light metals. Tensile strength on the order of 25,000 psi and yield strength of about 13,000 psi at 600 F are believed to be obtainable. It is doubtful, however, whether current improvements in this direction will be sufficient to halt the trend toward stainless steel and titanium as aircraft operating temperatures edge continually upward in this range.

FISSIONABLE MATERIALS

It may be possible to own or rent fissionable materials before too long. Liberalization of present restrictions on private use is believed to be one of a series of amendments to the Atomic Energy Act to be proposed by the Atomic Energy Commission shortly. Intended to increase the participation of private industry in the atomic energy program, these proposals have not yet been submitted to the President or to the Joint Congressional Committee on Atomic Energy.

MAGNESIUM DEVELOPMENTS

Large hot-rolled magnesium sheet and plate will shortly be available in quantity as Dow Chemical's new high production rolling mill gets into full operation. Hot-rolled plate, 6 ft wide and up to 60 ft long, is being made from 2000 lb rolling ingots on the new mill. Within a few months an 84 in. cold coil mill for finish rolling of thin-gage magnesium sheet is expected to be in operation at the Madison, Ill. plant. . . . Thin magnesium strip of greater flexibility is now possible with the development of a technique for preheating the strip immediately before reducing and maintaining temperature between reducing passes. Previously it has been difficult to prevent brittleness in the metal when rolled to 0.01 in. or less.

POLYETHYLENE COSTS LESS

Another price reduction for polyethylene has been announced by its largest producer. Most of this company's polyethylene resins can now be obtained at 41 cents per lb—a reduction of 3 cents per lb—in tank car lots. The new price tag follows the third price slash in little more than a year.

MORE TITANIUM

Small quantities of Japanese-produced titanium sponge are being purchased in this country. In addition to helping make up the gap between rolling capacity and sponge availability, the Japanese sponge is cheaper than the domestic material.... A leading producer of titanium expects to triple its daily output within a few months.

(Continued on page 4)

The Materials Outlook *(continued)*

LARGER THIN TUBING

Seamless light-wall tubing is now available in sizes up to 2-1/16 in. maximum o.d. Produced in stainless Types 304, 321 and 347, and Monel, the larger sizes of tubing are expected to make possible broader application of light-wall tubing particularly where pressures exceed the limits for welded tubing.

MORE POWERFUL TRANSISTOR

A tiny transistor with an output of 20 watts has been developed. Claimed to be about 100 times more powerful than present commercially available types, the device is about the size of a thimble. The greater power will enable the transistor to be used for the operation of motors, valves, relays and other equipment—jobs that cannot be handled with currently available transistors. Key to the development was the discovery of an effective method, not yet revealed, of removing heat from the germanium-metal junction.

NEW BURNISHING PROCESS

A new wet burnishing process claimed to cut metal finishing costs, compared to conventional wheel polishing and buffing, has been announced. The parts to be burnished move through an abrasive slurry where they come into contact with revolving rubber-fingered mats. Savings result from the durability of the rubber buffs and the reusability of the abrasive compounds.

LATEST X-RAY DEVELOPMENTS

A small self-contained x-ray source, potentially more flexible than radium or radon, is under development. It consists of a small amount of radioactive material surrounded by a layer of heavy metal. Quality and quantity of the x-rays produced as a result of Beta ray emission by the radioactive center can be regulated by varying the core material and the thickness and composition of the shell. The device can be designed to remain active for almost any time period desired. . . . Xeroradiography, a new x-ray process, is now being tested in its first field installation. The process employs a reusable dry plate and produces an image available for viewing within 45 sec. The image is produced by static electricity which arranges a fine-grain powder on a specially coated aluminum plate.

BI-METAL JOINT INSULATION

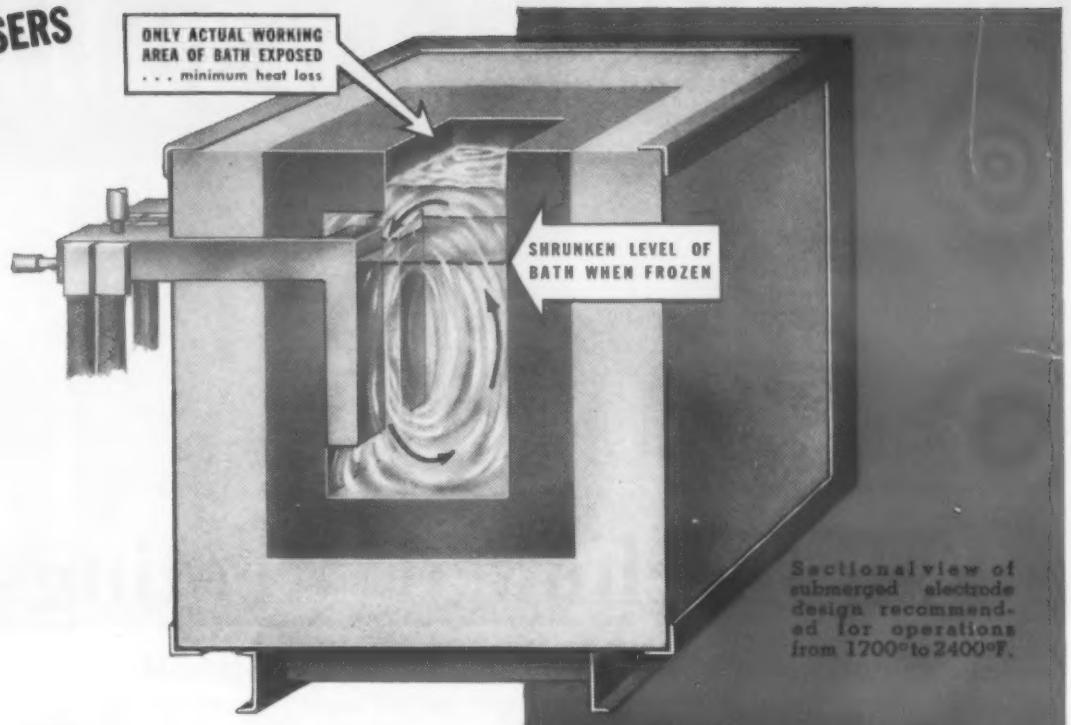
An impregnated tape specially designed to insulate aluminum from dissimilar metals at bi-metallic junctions is being marketed in England. The non-absorbent packing consists of open weave fabric impregnated on both sides with saturated petroleum hydrocarbons filled with metal silicates and containing a chromate inhibitor.

MATERIALS TESTING

Automatic "push-button" testing of materials using standard testing machines, new or old, is now possible with newly developed electronic control units. By using these program controllers in conjunction with tensile machines, any one or a combination of the following operations is now practical: automatic production and proof testing, stress or strain cycling, and yield strength by extension.

A FEW WELL KNOWN AJAX USERS

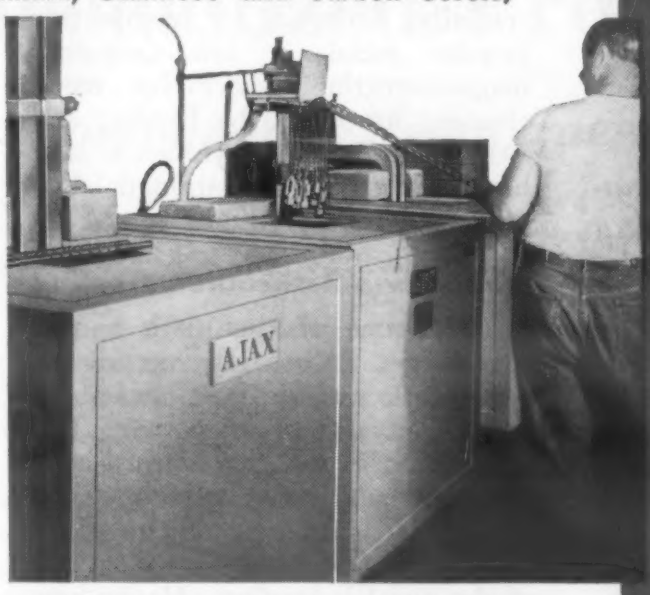
A. C. Spark Plug Division
Brown & Sharpe Mfg. Company
Commercial Steel Treating Company
Henry Disston & Sons Company
Ford Motor Company
Frigidaire Division
General Electric Company
Gorham Tool Company
Greenfield Tap & Die Company
Landis Machine Company
Midvale Company
Morse Twist Drill Company
Mueller Brass Company
National Cash Register Company
National Screw Company
Oliver Iron & Steel Company
Pratt & Whitney Division
Republic Steel Company
Stanley Works
Thompson Products Company
Threadwell Tap & Die Company
[illegible] Twist Drill Company
[illegible] Steel Treating Company
[illegible] Electric Company
Westinghouse Electric Company
. . . and dozens of others



Sectional view of submerged electrode design recommended for operations from 1700°F to 2400°F.

THE Preferred Practice FOR HARDENING TOOLS AND DIES

(High Speed, High Carbon-High Chromium, Stainless and Carbon Steels)



Typical installation for hardening high speed tools. Preheat, high heat and quench furnaces. The center unit operating at 2350°F. is equipped with submerged electrodes (see illustration at upper right). Preheat and quench units have suspended electrodes.

When such an imposing array of the world's leading makers of high speed tools and dies adopt the same heat treating method and equipment, you can count on it that there's a reason—several reasons in fact.

Productive capacity is two or three times that of other heat treating methods because of faster heating.

Distortion is negligible.

Surface protection is unsurpassed—because the salt bath seals the work *automatically* from all atmosphere. Scaling, decarb and pitting are avoided.

Temperature control is closer, more accurate. The temperature will not vary more than ±5°F *anywhere in the bath.*

The life of tools is increased from 25% to 300% over those heated by ordinary methods.

Adaptability—The Ajax Salt Bath handles any type of high speed, carbon or alloy tool and die steel. Moreover, it occupies less floor space, does not require a skilled operator and provides maximum protection and long life for pots.

Through this unique and patented Ajax submerged electrode design, the efficiency of salt bath hardening is increased in the following ways:

Power Consumption Decreased as Much as 30%—Only the *actual working area* of bath exposed.

Electrode Life Greatly Extended—Electrodes not exposed to severe oxidizing action at surface of bath.

Bath Rectification Simplified—Oxides and dross materially reduced due to restricted bath surface.

Restarting is Easy—Closely-spaced electrodes melt salt from top downward. No danger of sealed-in pressure. No damage to pot or electrodes.

Accurate Temperature Control—Electrodynamic circulation assures temperature uniformity within ±5°F throughout bath.

Overheating of Work Eliminated—Electrodes closely-spaced, set against back wall of furnace, prevent heating current from entering work. Entire bath depth available for work.

Salt Leaks Prevented—Complete outer steel casing.

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Write for Ajax Bulletin 123B

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AJAX ELECTRIC SALT BATH FURNACES

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New Materials Developments Spotlighted at . . .

Fall Technical Meetings

• ***For second year in row, titanium held feature spot in National Metals Congress.***

• ***Annual Magnesium Association Meeting highlighted non-military uses of magnesium.***

• ***American Standards Association's annual meeting stressed need for advance development of standards in atomic power and electronics.***

Capacity crowds at the titanium sessions of the Metals Show in Cleveland reflected high interest in the fast growing material on the part of engineers, metallurgists and manufacturers from all metal-using industries. Whether the members of the audience were using titanium or not, they were all anxious to keep up on the latest information on the metal and were impatient for the time when titanium would be available.

Release of the first data on all-alpha titanium high-lighted the AIME symposium. A report by Finley, Barcell and Durstein of Rem-Cru Titanium revealed that a new, moderate strength A-110 titanium-aluminum-tin alloy possessed superior formability, weldability, and high temperature characteristics. The report indicated that alpha alloys with yield strengths in the neighborhood of 140-150,000 lb are under development.

The Metals Exposition, held concurrently with the Metals Congress, nearly overflowed the space at Cleveland's Public Auditorium. As has been the tendency in the past few years, metal processing equipment dominated the exhibit. Among the many exhibits that attracted great interest: a new two directional press specially designed for compacting powder metal; a low frequency magnetostriction device for metal cleaning introduced by Bendix; and Beryllium, Inc.'s Beryldur, a new high-conductivity high-strength alloy of copper and beryllium.

Magnesium Association Meeting

The theme of the ninth annual Magnesium Association meeting in New York was the development of non-military uses of magnesium. The Association is openly concerned over the fact that a large proportion of magnesium is used in military products, while comparative civilian use of the metal is lagging. Magnesium processors were advised to go after any light metal field, as it is felt that aluminum has blazed the trail in winning public and technical acceptance for lighter materials.

A number of case histories of commercial magnesium parts and products indicated that magnesium technology is surmounting many of the problems it has faced in the past. Difficulties in fabrication are rapidly being solved. Alloys of magnesium and rare earths or thorium are proving serviceable in operating temperatures up to 600 F. These higher temperature alloys may help to overcome a serious barrier to the acceptance of magnesium. Flammability has proved a difficult hurdle, due to the widespread publicity enjoyed by magnesium incendiary bombs, flash powders, flares and, more recently, fuel.

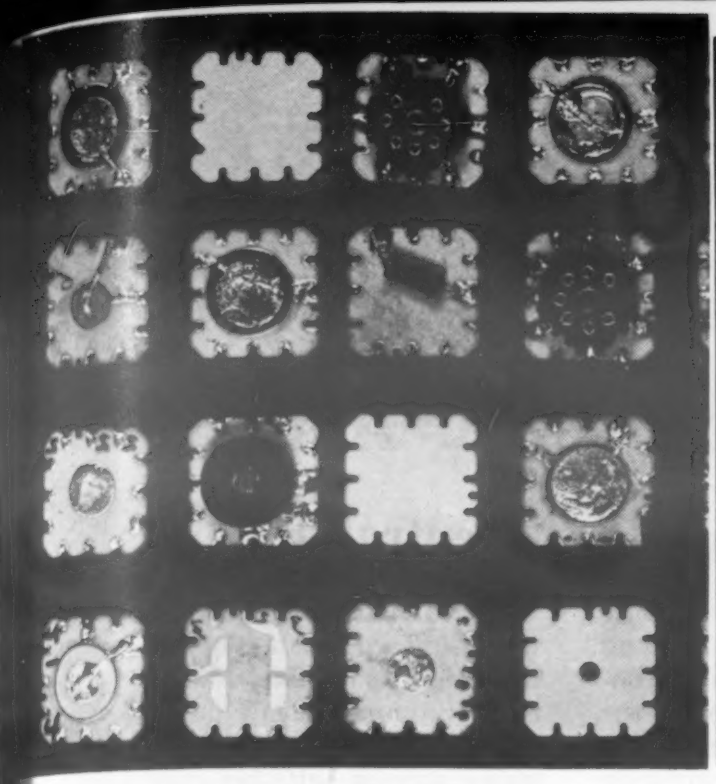
American Standards Association

Standards, unfortunately, are usually established after the fact. A city had to be destroyed before firehose couplings were standardized, the first world war was undoubtedly extended because Allied bullets and bolts were not interchangeable, and the growth of almost every new industry is invariably marked by a certain period of near-total confusion that requires considerable retrenchment and expense before standards are agreed upon that open the way to further progress.

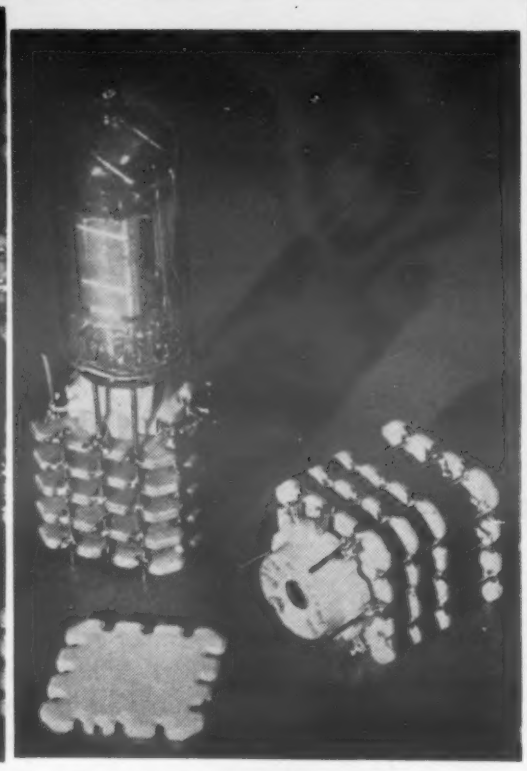
The fortieth annual American Standards Association meeting was devoted both to ex post facto clean-ups and to the prevention of "unstandardized" confusion in rapidly expanding industries.

The ASA's major clean-up operation dealt with industrial noise. Hearing loss data was presented for such deafeners as riveting, drop forging, and jet engine and armament testing. The work is the first step in establishing a long range program for standards in noise levels, noise control, and acoustic materials.

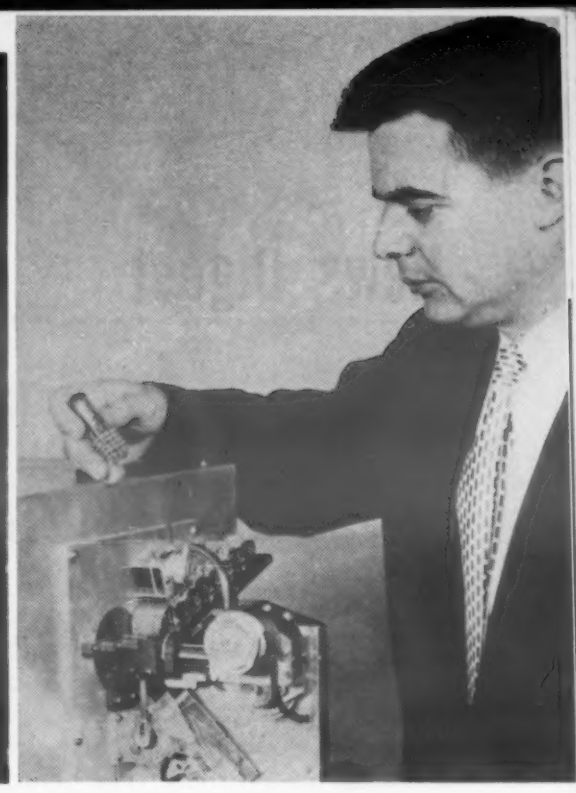
In an effort to avoid future confusion, the ASA warned industry that it is now time to settle on standards adapted to the materials and techniques of electronics and atomic power. The rapid rate of development of nuclear science and electronics, the association warned, will result in one of the most colossal messes industry has ever faced, unless immediate steps are taken to establish industry-wide standards along which orderly progress can develop.



Steatite wafers, on which resistor and capacitor components are mounted are automatically assembled to make...



. . . Modular units consisting of a single electronic stage. During production and assembly, all parts are tested in. . . .



Card programmed testing machines.

Versatile Electronic Module Simplifies Mechanized Production

Basic Electronic Components Re-engineered

The National Bureau of Standards and the Navy Bureau of Aeronautics have taken the security wraps off a radically new system for the design, fabrication and assembly of electronic products. The system produces electronic components from basic raw materials by fully automatic production techniques. The full scale automatic pilot plant that is now operating may be the prototype of the future electronic industry. The plant is open for industry inspection.

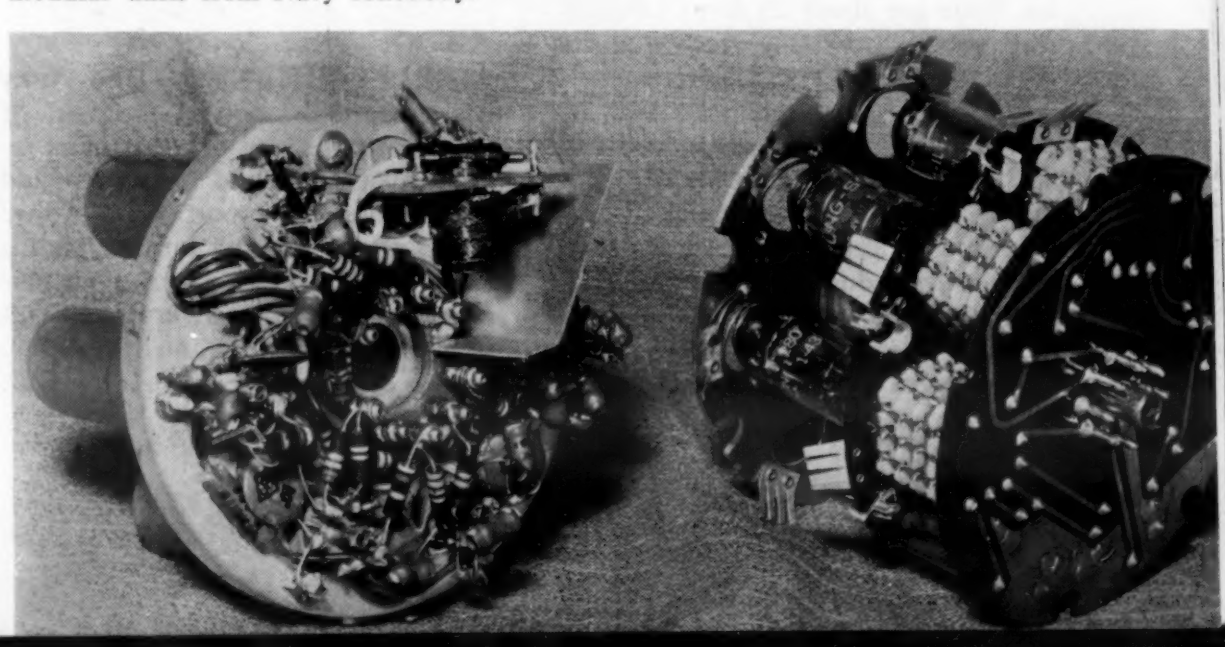
The project is unique in that the principles of electronics production have been completely rethought. Circuits have been redesigned physically around a standard module capable of carrying the circuitry of almost any single electronic stage. By interconnecting a number of modules by means of printed circuit bases, complete electronic circuits can be assembled. Perhaps most surprising and significant is the fact that the technique not only eliminates hand assembly, but also attains a degree of end product flexibility unheard of in the electronics industry. It is perfectly possible to change from one end product to another—such as from civilian radios to military aircraft components—in less than one working day. The NBS pilot plant offers convincing evidence that automatic production, properly planned, does not necessarily tie up capital in expensive single purpose machines that must be discarded or rebuilt in case of a change in the product they are producing.

The new system is the result of three years of research and engineering that cost close to $5 million. Most of that cost was basic development, of course, and a rough estimate of $1 to $1½ million is generally accepted as the cost of reproducing the present system with considerable refinement and improvements.

The NBS-Bu Aer project was codenamed "Tinkertoy", and the designation will probably stick, although efforts are being made to change it to "Modutronics". As conceived in 1950, the project called for a double edged program: The Modular Design of Electronics (MDE) to standardize electronics design, and Mechanized Production of Electronics (MPE) to develop a completely automatic system for producing the standardized components. While the automatic production techniques em-

(Continued on page 220)

Simplified assembly is apparent in comparison of analogous standard and modular units from Navy sonobouy.



News Digest

New SPI Division Preparing Standards

The Thermoplastic Structures Division of The Society of the Plastic Industry, Inc. has succeeded in establishing tentative standards for welding and chemical testing of polyvinyl chloride plastic sheet. The Structures Div., only slightly more than one year old, was formed by four fabrication firms in Oct. 1952 to work out industry standards for rigid thermoplastic structures based on polyvinyl chloride and polyethylene plastics resins. The Division now includes representation of 24 major chemical, rubber, and fabrication firms.

Structural products made from rigid unplasticized polyvinyl chloride and polyethylene include ducts, vents, storage tanks, tank liners, hoods, housings, pipe, fittings and other products. It is felt by the Structures Div. that many more applications are possible for rigid industrial structures made of these materials and that a well integrated period of growth will occur as the Division's program expands.

There are now six firms in the United States which produce rigid unplasticized polyvinyl chloride resins. These firms are: Bakelite Co., Dow Chemical Co., Firestone Plastics Co., B.F. Goodrich Chemical Co., Monsanto Chemical Co., and Naugatuck Chemical Div., U.S. Rubber Co.

Only two firms are producing polyethylene resins at present—du Pont and Bakelite, but Monsanto recently announced that it has a plant under construction in Texas City that will start producing in the fourth quarter of 1954.

In addition to the above companies, there are about 25 firms fabricating sheet and structural products from the plastic raw materials.

The SPI also announced that its new Vinyl Plastic Film Standard and Seal of Quality will be heavily promoted through an educational program to fabricators and processors in the plastics industry. The educational program will extend to the retail field in order to establish the standard and seal as a mark of approval in the use of plastics.

Looming Tariff Problem Faces Congressional Action

Raw Materials Play Central Role

The U. S. import policy is shaping up as one of the most critical items on the agenda of the next session of Congress. The looming expiration of the Reciprocal Trade Act on June 30 will force prompt and direct legislation that may set the future pattern of foreign trade, and most certainly influence the prices of many industrial materials.

Already partisans are marshaling forces for the traditional battle between high tariffs and free trade. The familiar old arguments, ranging from the free trader's principle of Comparative Advantage, "A country's resources should be allocated to their most productive use" to the rallying cry of the protectionists, "America's standard of living must be protected from low foreign wages", are getting dusted off, polished up and loaded with statistics.

International significance aside, the increasing importance of imports to this country's material economy—particularly imported raw materials that are not sufficiently available from domestic sources—attaches more weight than ever to the impending congressional action. It is something every material user should watch carefully.

While it is virtually impossible to summarize the whole problem of tariffs, with all the complex economic arguments and international and domestic politics that are involved, certain areas do reflect general trends of opinion, activity and actual need.

One major area, and perhaps the most important to the long range trend of world trade, is the raw material supply situation. Since the turn of the century the U. S. has changed from an exporter of raw

(Continued on page 224)

What They Said . . . . . .

ONE SIDE "We have allowed our nation to become unnecessarily dependent on strategic minerals from politically unreliable Asiatic, European and African sources. It is questionable whether those far flung sea lanes . . . could be defended. We will look into the dire straits into which this nation has been placed." *—Sen. George W. Malone, Chairman, Senate Interior Subcommittee, Sept. 1953.*

ANOTHER SIDE "We must focus our attention on the serious problem of strategic materials, for they are inexorably a part of the stake of U.S. business in world trade. Since it is a simple physical fact that many of the most essential strategic materials do not exist in the earth of this country they *must* be imported, come what may." *—J. Peter Grace Jr., Pres., W. R. Grace & Co.*

AIRLIFTABILITY? "The Army has embarked upon a program of lightening the load of the combat infantryman and the weapons and equipment to support him. Why? Not just to ease the burden on his back, not just to give him more personal mobility. It is a very important step in making him airliftable." *—Under Secretary of the Army E.D. Johnson, Aug. 1953.*

BULGING TEAPOTS "Economists tell us that people are presently adding to their liquid assets at more than $14 billion per year. This is double the rate of about five years ago. If even this incremental half of such savings were diverted into current purchases there would be continued good business rather than any feared recession." *— H.F. Smiddy, Vice President, General Electric Co.*

Materials BRIEFS

Hot Boxes An extensive program is underway to determine how much effect bearing materials have on the overheating of journal bearings used on freight cars.

Snakey Trick Lightweight Monel wire cloth is being used as a detachable lining for newly developed snakeproof trousers.

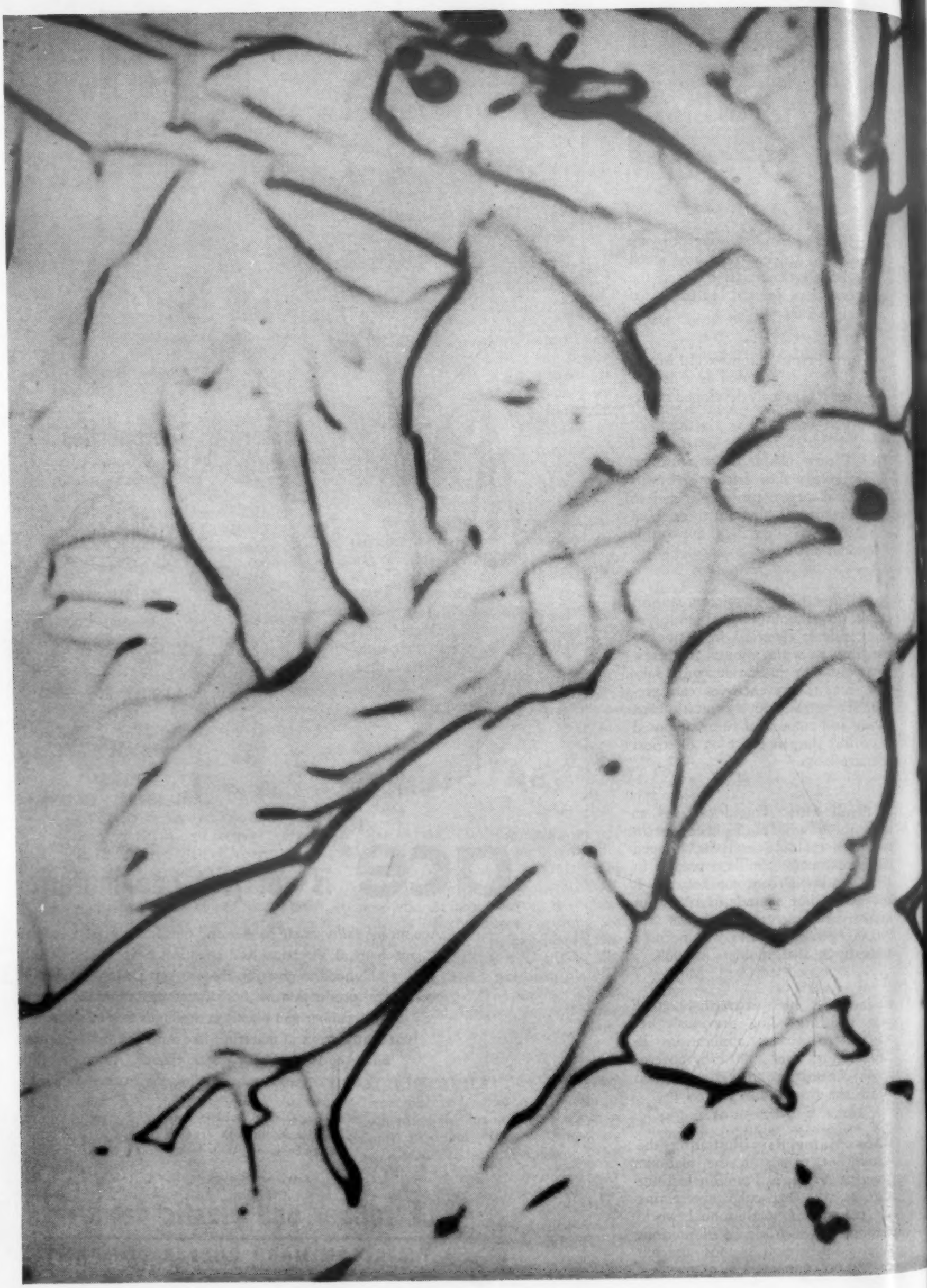
Hot Plane High temperature resulting from skin friction at near-sonic and supersonic speeds led to extensive use of titanium throughout the Air Force's new F100 Supersonic "Supersabre".

Bugbear Fungus microorganisms break down both natural and synthetic rubber electrical insulation by piercing it with minute filaments. Compounding insulation with suitable fungus preventatives can prevent or greatly delay attack, but choice and amount of fungacide used is critical due to effect on electrical characteristics.

A Shell Out Foundries used an insignificant amount of phenolic resin for shell molding in 1950, jumped consumption to 3 million pounds in 1952, and will consume between 8 and 10 million pounds in 1953. An industry representative predicts that 50,000,000 lb of resin will be used annually by shell molders in 1957.

Freed A high strength 2200 F heat resisting alloy previously restricted to service applications in temperatures over 2000 F by government controls on nickel will soon be on the market for general use.

Rare Material: Illustrating the scarcity of metals in the platinum group, a display at Franklin Institute features a 43 inch cube representing the volume of total annual world production. Such a cube of precious metal would weigh 23 tons, and sell for $50,000,000.



Phenolic housing for the Seeburg Mirror Speaker, a remote wall speaker, for commercial sound systems.

For Big Housings in Quantity the Answer May Be . . .

Large Plastic Moldings

Underlying trend to larger thermosetting moldings are new, improved resins and better production techniques and equipment

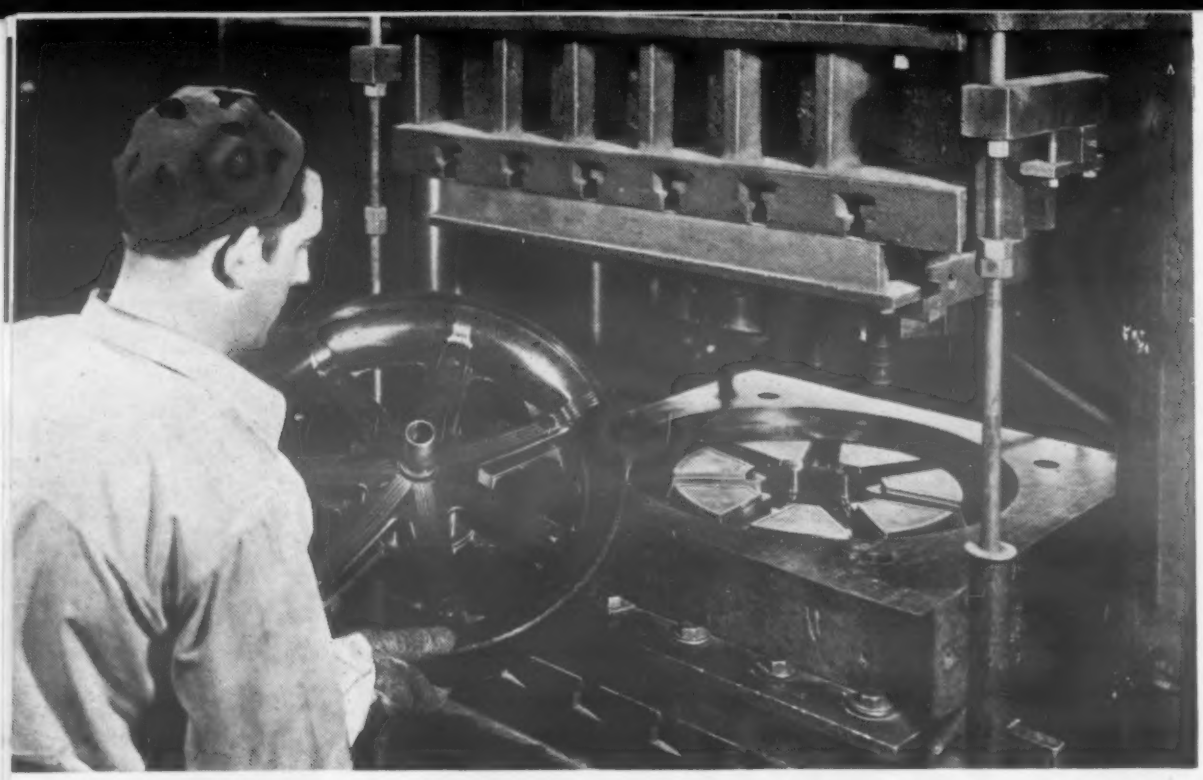
by JOHN B. CAMPBELL, Associate Editor, Materials & Methods

● THE PAST FEW YEARS have seen increasing acceptance of large unit housings molded from thermosetting plastics. Already well established in washing machine agitators and radio and TV cabinets, large plastic moldings are now expanding into the air conditioner, office machine and furniture fields.

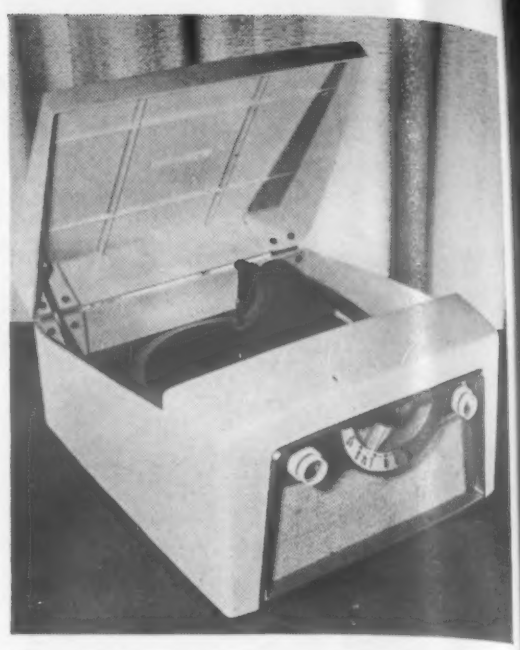
The trend toward increasing use of large plastic moldings is evident on the design, manufacturing and consuming levels. For the designer, plastics permit design with natural, functional lines unrestricted by many of the fabrication limitations imposed by wood and metal. For the manufacturer, plastics offer dimensional accuracy and uniformity, a one-step forming method suitable for mass production, and low labor costs. For the consumer, plastics mean products that are lightweight, "modern" in appearance, easily cleaned, resistant to water and other common liquids, and highly resistant to scratching or burning.

Underlying this trend is a program of continuing technical development. The most important technical developments contributing to the present trend have been new and improved molding compounds, new high-capacity press equipment and the use of high-powered electronic preheaters.

Of equal importance has been the educational program conducted by the Society of the Plastics Industry, through its Committee on Large Plastic Moldings. This cooperative effort is aimed at familiarizing industry with the unique possibilities in



This 19-lb molded phenolic wheel is the heart of the Cardineer Filing System. Notice the cylindrical bearing sleeve insert.



One of the largest urea moldings yet produced is the base of this two-piece housing for a combination radio-phonograph. Notice the ribbing designed to increase the rigidity of lid.

Urea meat scale housing weighs 70 to 80 lb less than the old porcelain-enamelled cast iron model. As a result it's easier to keep both scale and surrounding area clean.

design and manufacture offered by large plastic moldings, together with the technical and economic limitations that must be appraised for any specific application.

Advantages and Limitations

The principal advantages of large thermosetting plastic moldings, compared with other materials, can be briefly summarized as follows:

1. Good resistance to chemicals, including weak acids and alkalis and many commercial solvents.

2. Good electrical resistance properties.

3. Low thermal conductivity, a property that makes plastics relatively warm and pleasing to the touch, compared with metal.

4. Strength-weight ratio which is high enough to allow significant weight saving.

5. Adaptability to one-step production with a minimum of finishing.

6. Integrally molded color that does not wear, crack or peel.

7. Attractive designs achieved at low cost.

8. Greater dimensional accuracy and uniformity.

9. Unit cost up to 20% less in some cases where production volume is high.

Some of the main limitations of large plastic moldings are:

1. Relatively low strength and modulus of elasticity limit severe loading of thin sections, often necessitating integrally molded reinforcement.

2. Lack of stability at high temperatures. Standard commercial materials can withstand temperatures up to about 400 F; some special materials are good up to 500 F.

3. Relatively steep decline in strength at temperatures approaching 300 F.

4. Limited abrasion resistance compared to ferrous metals and ceramics (though superior to wood, aluminum and painted metals).

5. Need for metal inserts where threaded sections will be subjected to loading or wear.

6. High tooling cost, which limits most applications to high-volume products where amortization gives low unit tooling cost.

7. Unsuitable for prototype models because of the tooling investment. Hence, prototypes must be made in other materials.

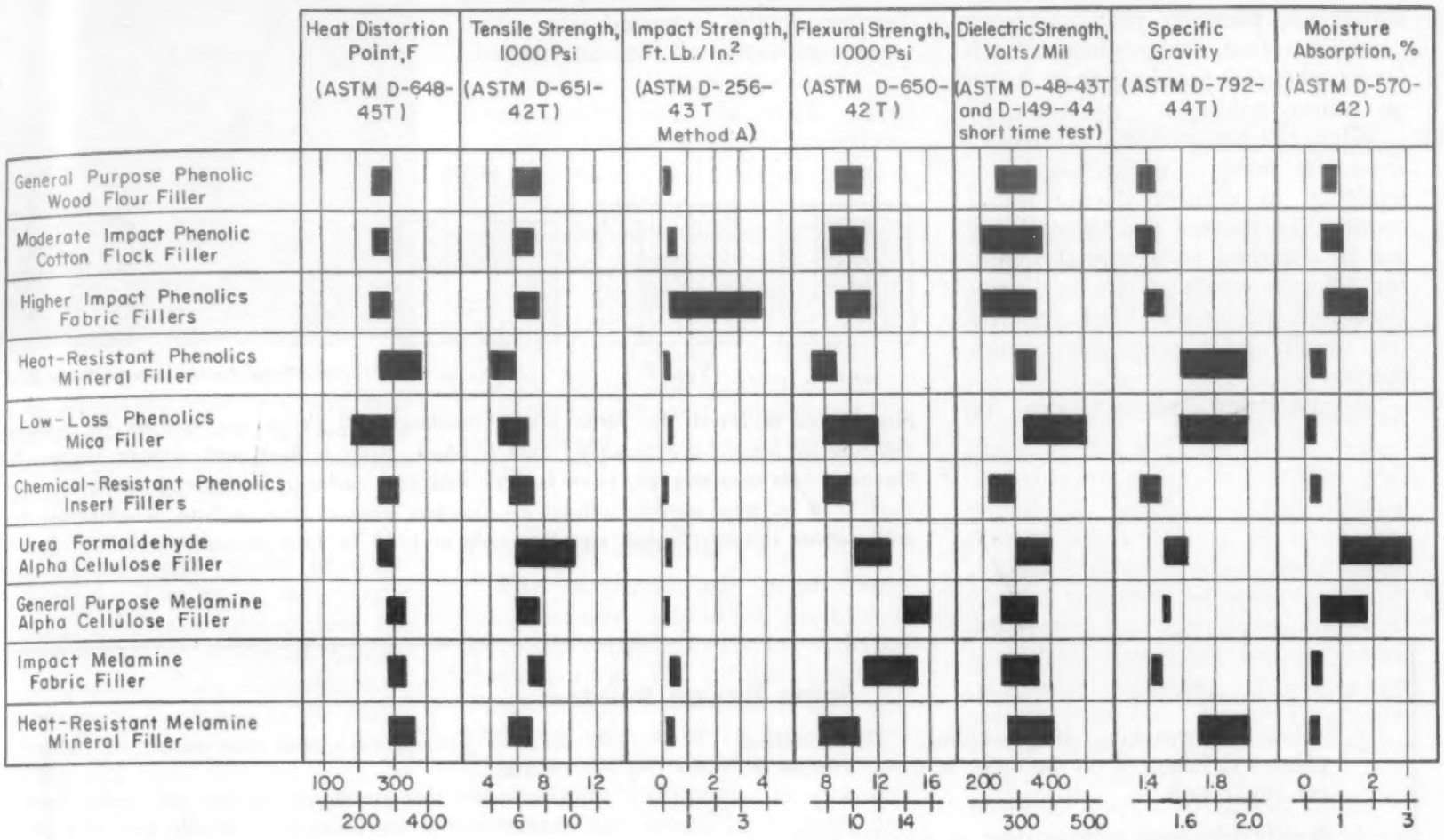
The Materials

Thermosetting materials are the class of plastics best suited for large unit moldings. The higher strength and surface hardness of the thermosets, compared to thermoplastics, makes them particularly suitable for housings subjected to ordinary service loads and occasional impact loads. Their resistance to softening at temperatures of several hundred degrees is also important in certain applications, particularly in the electrical field.

Three types of thermosets are being used commercially for large unit moldings. They are the phenolics, the ureas and the melamines. Each type offers its own peculiar advantages and limitations. In addition, each type is amenable to variations in composition and processing that make possible materials with properties specifically adapted to given applications. Some idea of the extent of the variations possible can be ascertained from the accompanying chart showing the range of properties for various types of compounds.

Phenolics—Phenolics are by far the most widely used material in large plastic moldings. They have good chemical resistance, water resistance, impact strength, electrical resistance, dielectric strength and surface hardness. The property that distinguishes them from other thermosets currently available, however, is their superior moldability. With the high-compression molding equipment now available, it is possible to mold phenolics in units weighing up to 60 lb, with a draw of 24 in. and a projected area of 24 to 48 in. The favorable flow characteristics of phenolics make possible complex designs. Another important factor is the low cost of phenolics compared

Range of Properties for Thermosets Used in Large Plastic Moldings



to other thermosets. As the accompanying table shows, ureas and melamines ordinarily cost from 50 to more than 100% more than phenolics. Chief limitation of the phenolics is color. Generally phenolics are available only in dark colors. Light colors tend to fade with time, particularly when exposed to sunlight.

Ureas—The ureas, higher in cost than the phenolics, are used only where their peculiar advantages are considered worth the premium. The most important advantage is color. Unlike the phenolics, the ureas can be obtained in any color from white to brilliant hues, including pastels. Nearly all shades are commercially lightfast. Another important advantage is the absence of odor or taste. The ureas also have better arc resistance than the phenolics. Chief disadvantages, compared to the phenolics, are the need for close control in molding to maintain purity of the material and the need for higher molding pressures. The ureas also have a greater tendency to absorb moisture.

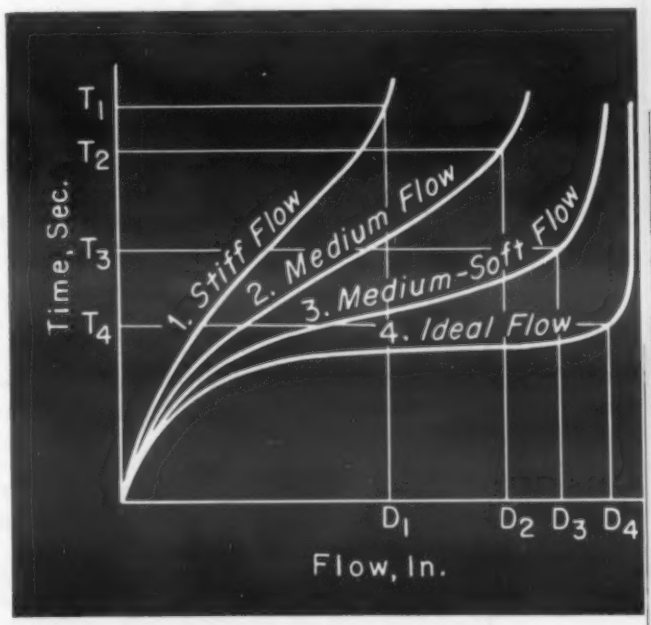
Average Prices of Thermosetting Molding Compounds

Material	Price, cents/lb
Phenolic	22-28
Urea	33
Melamine	47

Melamines—Still more expensive, the melamines are quite similar to the ureas but have certain advantages for specific applications. They have better water resistance and somewhat higher resistance to dilute acids and alkalis. Unlike the ureas, they are compatible with mineral fillers. This makes possible moldings with greater strength, impact resistance and heat resistance, as well as better arc resistance. Melamine moldings also have harder surfaces and, therefore, greater abrasion resistance.

Molding

Compression molding is the method most commonly used for the production of large unit housings in thermosetting materials. Large presses, rated at 300 to 3000 tons, are needed. The molding compound is usually bricketted and electronically preheated. The material is then placed in the steam-heated, closed-die mold, the die is closed, and pressures up to 10,000 psi or higher are applied. The mold remains closed until polymerization occurs. It is then opened and the part ejected.



Flow characteristics of phenolic molding compounds. Constant pressure and temperature are assumed. Current materials development aims to approach the relatively ideal flow behavior of Curve No. 4. As indicated, improved compounds provide not only greater flow but a faster cycle.

The length of the molding cycle and the pressures and temperatures needed depend on the particular molding compound used. The accompanying graph shows, qualitatively, how the flow characteristics of a phenolic molding compound can be varied. Ureas and melamines are faster curing and have stiffer flow characteristics than phenolics; as a

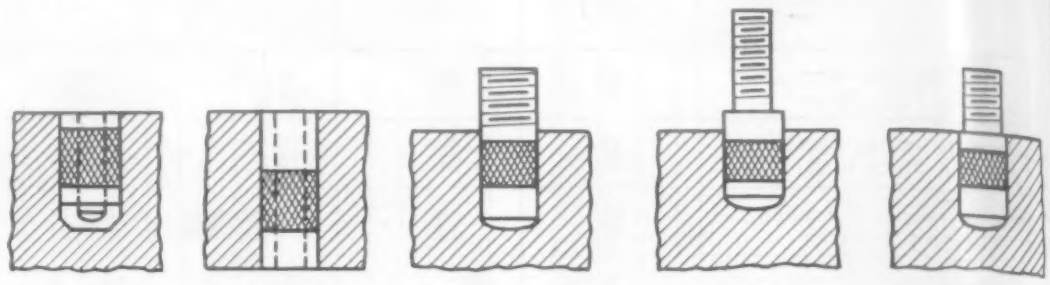
result they require higher molding pressures than those needed for an equivalent phenolic part. A given press, therefore, can produce a much larger phenolic molding than it can an amino molding.

When the hot molding is removed from the press it sometimes has a tendency to deform during initial cooling. To prevent this the molding can be attached to a special fixture for 3-5 min which maintains dimensions and alignment. Flash removal can usually be accomplished simultaneously.

Thermosetting plastics can be transfer-molded, but this method is not generally used for large molding because of the increased size, compexity and cost of the die needed.

Design

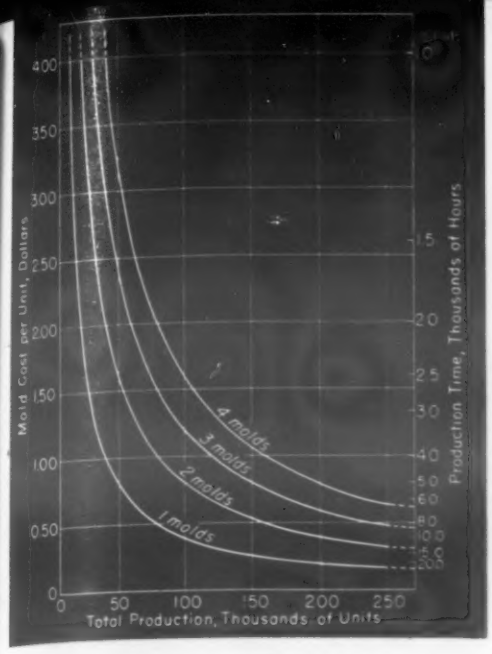
The concept of "designing for plastics" as opposed to mere substi-



Basic types of inserts for large plastic moldings. All heads are knurled for adequate gripping by plastic. A—Threaded hole is blind; insert is flush with outside surface. F—Threaded hole runs through; insert is flush with both surfaces. L—Insert is straight; threads start 1/16 in. from outside surface. P—Shoulder projects from surface. R—Shoulder flush with outside surface; threads start minimum of 1/32 in. from shoulder.

Some Design Pointers

1. Allow for shrinkage after molding. Thermosetting plastics shrinkage is on the order of 0.002 to 0.10 in. per linear inch.
2. Specify tolerances only as close as actually necessary. Tolerances closer than 0.005 in., the usual commercial limit, generally raise costs.
3. Allow a minimum draft of ½ to 1 deg. to facilitate removal of the part from the mold.
4. Avoid undercuts. Undercuts require split-cavity molds, lowering production rate and raising unit cost.
5. Locate the mold parting line in one plane. An irregular parting line introduces additional tooling cost.
6. Locate holes at right angles to surfaces. Oblique holes add to mold cost.
7. Avoid long cored holes, especially horizontal ones. Otherwise it is necessary to provide support for the core pin.
8. Avoid locating projections near corners or edges as this necessitates a relatively weak section in the mold.
9. Design projections round. Irregular-shaped holes are expensive to produce in the mold.
10. Locate all holes and projections in the direction of mold and press closing. Otherwise holes must be formed by means of retractable core pins, adding to mold cost.
11. Locate lettering to be embossed or debossed on surfaces parallel to the mold parting line.
12. Arrange that marks made by mold ejection pins occur on surfaces to be concealed.
13. Design grille elements parallel to flow of plastic in mold to minimize obstruction.
14. Continue grille lines as a false grille. Where grille lines must terminate in a flat face, break plastic flow in molding by changing the surface plane.
15. Inserts (see above)
    a. Use brass inserts rather than steel, as their coefficient of thermal expansion more nearly equals that of plastics.
    b. Use inserts that are sturdy and not too small. Small fragile inserts are difficult to handle and slow the molding cycle.
    c. Avoid long slender inserts, since molding pressures may deflect them out of position.
    d. Make the plastic section around an insert heavy enough to hold the insert securly and prevent cracking after molding.
    e. Make the projecting portion of projecting inserts round for minimum mold cost.
    f. Design projecting threaded inserts with a slightly projecting, unthreaded shoulder to prevent plastic from filling threads in molding.
    g. Always specify metal inserts for small, threaded holes (No. 6 or smaller) when the thread will be subjected to mechanical stress or wear.
16. Specify as shallow a draw as feasible. Deep draws require higher molding pressures, thus restricting the types of presses that can be used.
17. Design toward uniform section thickness and uniform distribution of mass for optimum flow of plastic in molding.
18. Round corners. This makes possible a more durable mold and improves the flow of plastic in molding.
19. Use fillets and ribs to add strength and minimize distortion from warping, as well as improve the flow of plastic in molding.
20. Avoid sharp discontinuities that might become areas of stress concentration, particularly where internal ribbing is used for support.
21. Restrict rib thickness at root to no more than that of the adjacent wall, and rib height to no more than twice the thickness of the wall section. Otherwise "sink" marks may occur on flat surfaces opposite internal ribs due to plastic flow characteristics.
22. Break up large flat surfaces with beads, steps or other geometrical devices to increase rigidity. Improved appearance can often be obtained.



Relationship between total production, number of molds, unit mold cost and total production time. Graph assumes a mold cost of $40,000 per mold and a production rate of 10 per hr for each mold used.

tution of materials cannot be overemphasized. Designers of plastic moldings must take into account the inherent service properties of thermosetting plastics. They must also visualize the part in relation to the mold, particularly the materials flow during molding and how the part is to be removed from the mold. And, recognizing the importance of the tooling investment, they must try to avoid unnecessary complicated shapes that increase mold cost disproportionately. A fairly comprehensive list of practical suggestions for good design is included with this article (see Some Design Pointers).

In many cases, additional mold cost is easily justified by savings in the cost of manual operations. Integral projections, holes and threads, for instance, run up tooling costs considerably but often contribute to a less expensive product.

Integral lettering is usually more durable and attractive than that produced by hot stamping. Hot stamping is often preferable, however, where small, fine lettering is needed or where the lettering is subject to occasional change. Where integral lettering is used, raised lettering (on the part) is more economical than embossed lettering.

Tooling

As already indicated, tooling cost is an important factor in determining the feasibility of a large plastic molding for any given application. Two factors often tend to increase the tooling investment. One is the need for production at a rate higher than can be accomplished with a single mold. In this case one or more duplicate molds may be necessary. Assuming the same total production volume, the unit mold cost is correspondingly higher. The other factor is obsolescence. Some products require frequent changes in styling to keep pace with competition and consumer preference. In such cases, molds become obsolete before their life is exhausted and must be replaced with new molds. Techniques being used to keep such costs at a minimum include the use of a removable mold face that can be interchanged with faces of new design, and the use of layer molds in which the laminations can be interchanged. In these ways an entirely different appearance can be achieved without changing the entire mold.

Production and Cost

The accompanying graph summarizes some important production and cost considerations for a hypothetical 27-lb TV cabinet molding. Production rate per mold is assumed, conservatively, to be 10 units per hr. Tooling cost per mold is assumed to be $40,000 (although, in practice, some savings would be possible for duplicate molds) and materials cost is based on a price of 22 cents per lb. The materials cost per unit is therefore $5.94.

Based on these figures, the mold cost per unit for a production run of 1000 TV cabinets is $40.00 or almost seven times the materials cost. For 10,000 cabinets, the unit mold cost is $4.00, and for 100,000 the unit cost is down to $.40, less than 7% of the materials cost. However, a production run of 100,000 with one mold would require 1250 8-hr shifts, or more than a year even on a round-the-clock schedule with no down-time. Use of four molds would cut production time to about 315 8-hr shifts, but, on the other hand, would increase mold unit cost to $1.60. Another factor that must be considered is the tremendous increase in mold-making time where machine shop facilities are sufficient to handle only one mold at a time. These considerations demonstrate clearly the importance of determining the total volume needed in the early stages of planning.

The savings to be expected in comparison with wood or metal fabrication vary with the product and the production volume. The experience of one radio manufacturer indicates that tooling costs for a metal cabinet are about twice those for a plastic cabinet. This company's estimated total cost index for plastics, metal and wood cabinets is as follows:

Plastics	100
Metal	110
Wood	120

These costs are based on a single plastics mold and would have to be modified if total volume necessitated a higher production rate.

The Future

Current research and development points to a number of advances in thermosetting molding materials in the next few years. In the ureas, for instance, much effort is being devoted to the improvement of molding characteristics to the point where they compete more readily with phenolics for large moldings. Dark-colored ureas, selling at about the price of phenolics, are a recent development intended to erase the price differential that has always mitigated against the use of ureas except where color was important. The low-cost ureas are achieved by relaxing some of the stringent controls on purity that are needed to produce the conventional pure transluscent colors.

A reverse twist may be supplied within two years by the advent of light-colored phenolics, now under laboratory development. Another project is a phenolic with an arc resistance comparable to that of the melamines. A recent development is a glass-fiber-filled material with an impact strength of 26 ft lb/in.^{2}, tensile strength of 24,000 psi and flexural strength of 65,000 psi. Phenolics with better chemical resistance, better heat resistance and shorter curing times are also on the way.

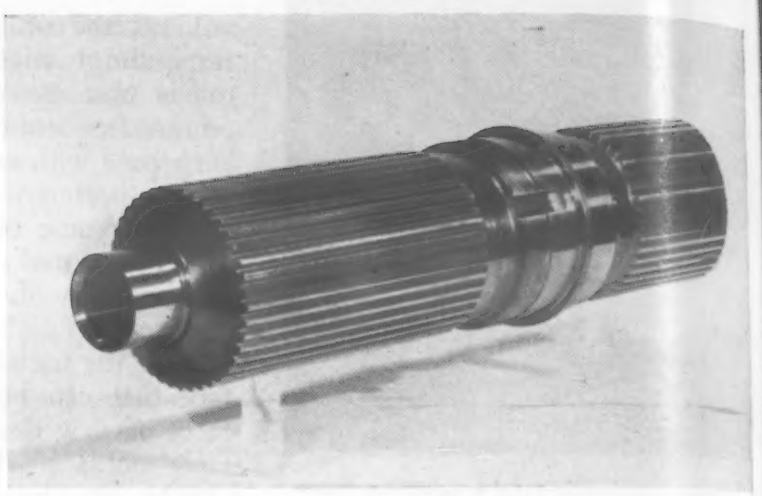
Concurrent with the development of improved plastics molding compounds, continued advances in molding technology and cost reductions can be expected. With constantly improving materials and processes available, the outlook is for increasingly broad use of large plastic moldings.

Acknowledgment

The information on which this article is based was obtained from the SPI Committee on Large Plastic Moldings which has the following members:

American Cyanamid Co.
American Insulator Corp.
Bakelite Div., Union Carbon & Carbide Corp.
The Borden Co.
Chicago Molded Products Corp.
Durez Plastics & Chemicals, Inc.
General American Transportation Corp.
The General Industries Co.
Monsanto Chemical Co.
Molded Products Corp.
Plaskon, Barrett Div., Allied Chemical & Dye Corp.
Plastics Engineering Co.
Prolon Plastics Div., Pro-phy-lac-tic Brush Co.

PLANETARY CARRIER of SAE 4340 steel has lower spline nitrided at 950 F for 55 hr. Case depth is 0.020 to 0.025 in. and case hardness is 87 Rockwell 15 N, minimum.



CLUTCH SHAFT of Nitralloy 135 modified steel has spline nitrided at 975 F for 65 hr. Case depth is 0.018 to 0.023 in. and case hardness is 92 Rockwell 15 N, minimum.

Nitriding Critical

Core strength improvement by heat treatment plus surface hardening by nitriding raises wear resistance, fatigue strength, and bearing properties.

● IN THE MANUFACTURE of helicopter transmissions at Ford Instrument Company, certain of the component parts are subjected to excessive wear in service, combined with high torque loads. Consequently, these parts are made from steels heat-treated for sufficient core strength and nitrided for high wear resistance. Parts with mating splines which slide over each other are nitrided for wear resistance and to prevent seizing and galling. Bearing diameters of other parts are nitrided to permit the installation or replacement of press-fit bearings with no damage to the bearing surface. Replacement and maintenance costs are held to a minimum by nitriding.

Steels Used

Parts requiring nitriding are made from Nitralloy 135, Modified (AN-S-19a, Comp A) or SAE 4340 (MIL-S-5000) steel. Before nitriding they are hardened in atmosphere controlled furnaces and tempered at 1025 to 1050 F to produce core hardnesses of Rockwell C 34 to 36. After this treatment, parts are semi-finished machined and given a stress relief anneal to minimize distortion during nitriding. They are then finished machined and prepared for nitriding.

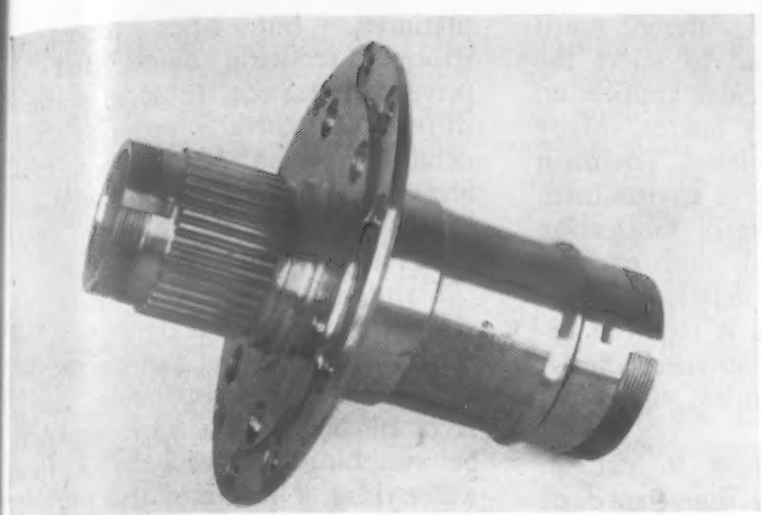
In the preparation of parts for nitriding, certain areas are copper plated to prevent penetration of nitrogen. Before plating, parts are degreased and cleaned electrolytically by being made the anode in an alkaline bath. Unless cleaning is thorough, blistering of the copper plate will occur during nitriding with the result that hard spots will form in areas intended to remain soft. This can be troublesome, as excessive distortion can occur because of the great differential in hardness between core and case at adjacent areas. This is especially true in thin-walled cylindrical parts made from Nitralloy 135 Modified steel, because of a minimum core hardness of 34 Rockwell C adjacent to a case hardness of 65-70 Rockwell C.

Areas which are to be nitrided are protected with masking paint or rubber masks to prevent plating. Parts are then given a flash copper plate and transferred to the plating bath. Here they are copper plated to a depth of 0.0015 to 0.0020 in. by using the Unichrome Pyrophosphate Copper Process developed by United Chromium, Inc. This process yields a smooth, bright dense deposit which is very effective as a stop-off for nitriding.

Nitriding Steps

It is obvious that nitriding must be carried on at temperatures below the tempering temperature used to develop the core properties, otherwise a drop of core hardness will result. Consequently it is essential that the parts be made from alloy steels containing elements like chromium, molybdenum, singly or in combination, so that tempering temperatures higher than nitriding temperatures can be used.

Nitriding is done in Leeds & Northrup furnaces equipped with gas-circulating fans, cooling chambers and dissociation pipettes. Parts are loaded in the furnace with ample space between each to provide free circulation of ammonia. Three samples of the same composition and core hardness as the parts they represent are placed at the top, middle and bottom of the charge to check the uniformity of case depth from top to bottom of the load. All furnace charges are logged and a



SUN GEAR SHAFT of SAE 4340 steel has bearing diameters nitrided at 950 F for 47 hr. Case depth is 0.018 to 0.023 in. and case hardness is 87 Rockwell 15 N, minimum.

SHAFT EXTENSION of Nitralloy 135 modified steel has spline nitrided at 975 F for 65 hr. Case depth is 0.018 to 0.023 in. and case hardness is 92 Rockwell 15 N, minimum.

Steel Parts

by **RALPH SPAGNOLA,** Metallurgist, Ford Instrument Co., Div. of The Sperry Corp.

permanent record of each heat nitrided is maintained. After the furnace lid is lowered into its oil seal, the furnace is purged at 300 F with anhydrous ammonia until a reading on the dissociation pipette indicates 10% air remaining in the furnace. This is important, as excess air will oxidize the copper plate during heating to the nitriding temperature, and adversely affect its stop-off properties. The furnace is then brought to the nitriding temperature for the steel involved and the time cycle is adjusted to produce the desired case depth. The degree of dissociation is maintained between 30 and 40% for parts that are to be ground after nitriding. For parts that are to be lapped after nitriding, dissociation is maintained between 60 and 70% thus eliminating the so-called "white layer" in the finished case. The degree of dissociation is controlled by adjusting the ammonia flow to the furnace, decreasing the flow for high dissociation and increasing for low dissociation. Furnace temperature and dissociation are checked every hour and recorded on the furnace temperature control chart.

On parts made from 4340 steel, a temperature of 950 F maintained for 55 hr, produces a case depth of 0.020-.025 in. The hardness obtained is 87-89 Rockwell 15N. Nitriding at 925 F to produce the desired depth would require a much longer cycle than would be practical, although a higher case hardness would result. To nitride at 975 F would require a shorter cycle than at 950 F; however the case hardness obtained would be below the 87 Rockwell 15N minimum required. A case depth of 0.018-0.023 in. is obtained on Nitralloy parts by nitriding at 975 F for 65 hr. The resulting case hardness is 92-94 Rockwell 15N. Since both steels were tempered at 1025 to 1050 F, nitriding in the range specified causes no reduction in core hardness.

After nitriding is completed, the furnace is cooled to about 200 F. Channeling the hot gases through a water-cooled chamber cools the charge at the rate of approximately 100 F per hr. After the furnace has cooled to 200 F, it is purged with compressed air slightly above atmospheric pressure. This prevents any ammonia gas which may remain in the furnace from contaminating the air in the room when the lid is removed. The three test samples are polished, etched and examined under the microscope for case depth and character. Results are permanently recorded.

Work emerges from the furnace with the nitrided areas having a dull gray appearance. The copper plate remains bright indicating that the initial purge with ammonia was sufficient to prevent oxidation. A representative sample of parts is checked for case hardness using the superficial Rockwell 15N scale. Copper is stripped from the parts in an alkaline electrolytic bath containing Unichroms Strip Salt No. 81, which leaves the steel clean and free from etching or pitting. After stripping, the parts are either finished ground or lapped depending on the specifications for finishing. To insure meeting the hardness requirements, all finished parts are given a Rockwell hardness test.

Although many consider the cost of nitriding high, it is worth noting that in the three years the Ford Instrument Company has been producing helicopter transmissions, there has never been a report from the field that nitrided parts have failed in service because of excessive wear, seizure, galling, or failure in fatigue.

Which Stainless Steel?

Corrosive environment, service conditions and fabrication methods must be considered in deciding which of these grades is most suitable for a given application.

● THERE ARE MANY different kinds of stainless steel, and to select the right one for a particular application is not always an easy matter. Many factors must be considered. The main ones are exact corrosive environment and service conditions, fabricating methods to be used, and part or product design. A detailed knowledge of these factors is required because even slight variations can make a given grade of stainless vulnerable to corrosion.

This article attempts to explain the significance and importance of these selection influencing factors. It also is planned to help the prospective stainless user by summarizing the principal properties of the major groups of stainless steel.

Selection Considerations

Corrosive Environment—In corrosive environments of an oxidizing nature the stainless steels display a nobility approaching that of silver or platinum. But when placed in strongly reducing media and deprived of oxygen, these alloys may shift up the galvanic series to a vulnerable position near carbon steel. Strongly reducing solutions, the acid halide salts especially, are a signal for caution in applying stainless.

Stainless steel resists corrosion best when all its surface is oxidized. This occurs in the air but can be speeded by passivation, an operation usually accomplished with a nitric acid bath or swabbing followed by a fresh water rinse. Nitric acid also provides chemical cleaning and removes any stray iron which might become a focal point for localized attack.

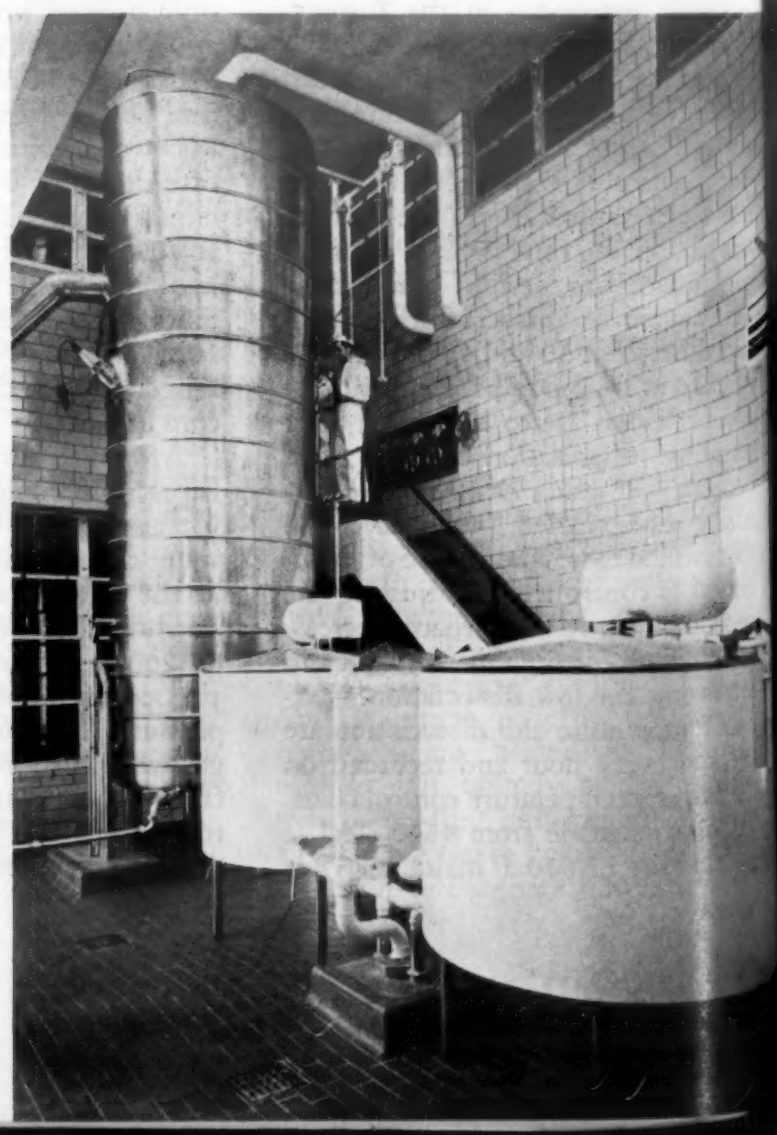
The conditions under which stainless steel is used are important in minimizing corrosion. Liquids should not be allowed to remain stagnant in contact with stainless steels for long periods. Unequal concentrations caused by gravity, evaporation, and other causes should be avoided by stirring, faster processing cycles,

12% Chromium

Steam turbine blades are usually made from Type 403 to obtain good strength at elevated temperatures, and resistance to the corrosive and erosive effects of hot steam. Other typical applications: cutlery, hardware, machinery parts and valve and pump parts.

18:8 Chromium-Nickel

Food processing equipment such as this vacuum pan for the production of condensed milk is frequently made of Type 302, most widely used of the stainless steels. Other typical applications: fasteners, home and industrial appliances, drums and barrels.



draining tanks not in use, etc. Deposits left by evaporation can often cause trouble, and should be prevented if possible, or frequently flushed away.

Stainless steel equipment should be protected against overheating. Unless "stabilized", or unless the carbon content is extremely low, austentic stainless steels become susceptible to corrosion upon being held between 800 F and 1600 F for an appreciable time.

Many chemicals that are only mildly corrosive when pure, become difficult to handle if they are mixed or if they contain certain impurities. Contaminated acids and fuels containing sulfur are examples. Other so-called impurities may suppress corrosion; for example copper compounds in sulfuric or phosphoric acids. Possible impurities must therefore be carefully accounted for before a stainless type is decided upon for tanks, piping, etc.

Fabrication Methods—When appraising a type of stainless for a piece of equipment it is important to keep in mind the fabrication processes to which it will be subjected, since these can affect the metal's performance.

For example, whenever the alloy is to be welded or brazed, or used for some time in its sensitizing temperature range, chromium carbide may precipitate at grain boundaries. The same result can occur because of improper heat treatment. The metal may then display reduced corrosion resistance. Some carbide precipitation can usually be tolerated. If the corrosive conditions are severe, though, grain boundaries with carbide will be attacked first. Weld decay, or deterioration along welds in heat-affected zones is a good example of intergranular corrosion. Such chromium carbide precipitation can be minimized by using a very low carbon-containing stainless, by proper heat treatment after carbide precipitation, or by using columbium or titanium stabilized stainless steels.

Design—Corrosion resistance is also a function of equipment design. Designing equipment without crevices has proved most desirable. Small internal radii should be eliminated, if possible, inside corners filleted, seams kept at a minimum, and welds ground smooth. Faying surfaces of joints between stainless and other metals should be eliminated or insulated. Wood and other porous materials absorb and slowly build up high concentrations of corrodents. In the restricted oxygen-poor area of a joint (especially under gaskets) active corrosion can proceed easily.

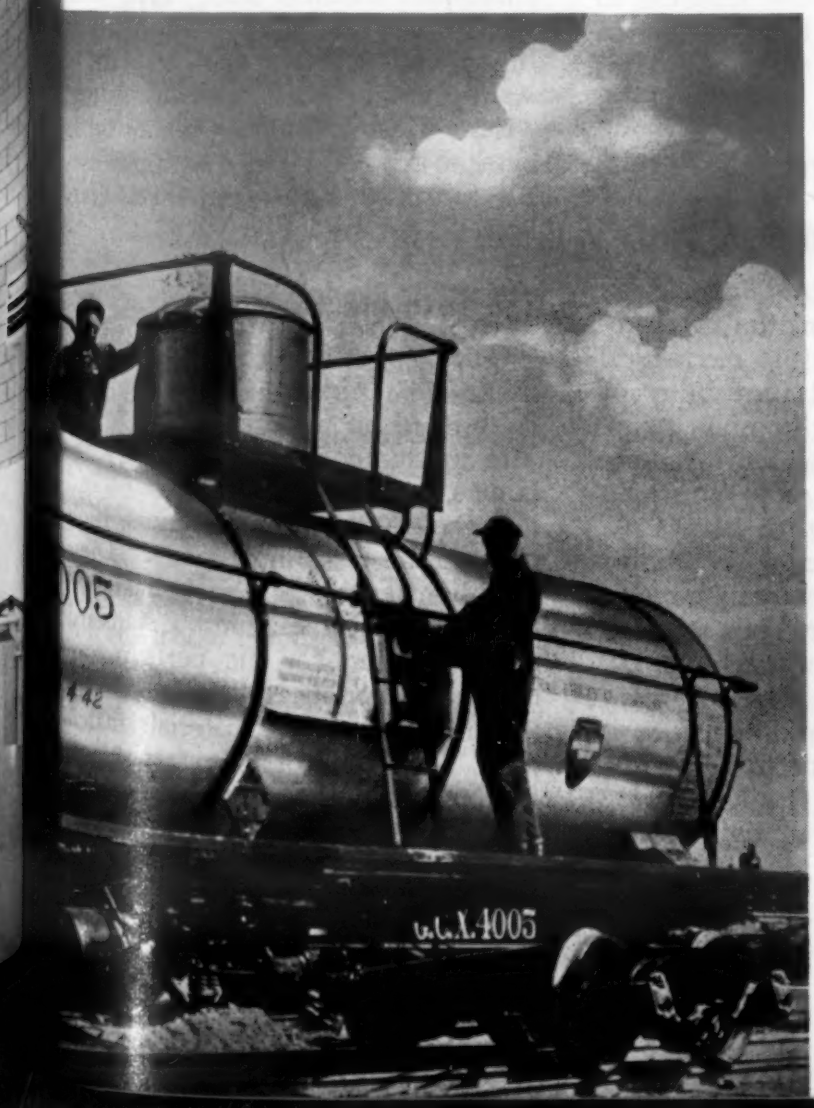
Gaskets or packing containing graphitic materials accelerate such action. Plastics, fiber, or synthetic products containing asbestos should be specified instead. Zinc chromate paints should be used to separate stainless steel and wood.

A designer should not count on same behavior in fabricated metal as seen in sample corrosion tests. Corrosion resistance is a property of the

by RICHARD E. PARET, Stainless Steel Specialist, American Iron and Steel Institute

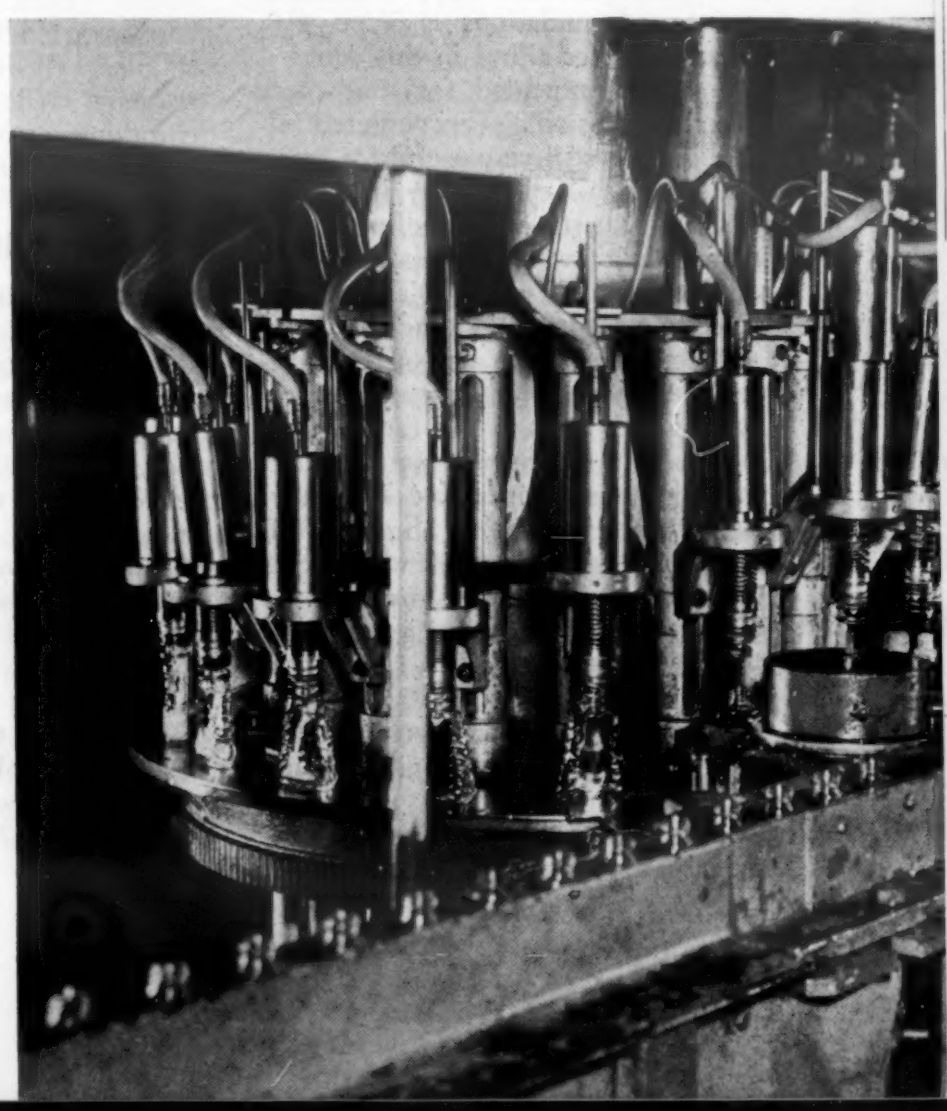
17% Chromium

Type 430 is as resistant to nitric acid as 18:8 and is used in quantity in nitric acid processing and transportation equipment. Other typical applications: auto trim, TV tube cones, ball bearings, surgical equipment and fasteners.



18:8 Molybdenum

Type 316, a molybdenum-bearing 18:8, is used in this bottle filling machine. Other typical applications: chemical process equipment, heat exchangers, photographic equipment.



particular type, the way it is fabricated, and the environment in which it is being used. A slight change in fabrication or (more often) in the environment can completely invalidate conclusions based on a laboratory test. If the alloy with the greatest corrosion resistance is always specified, the likelihood of successful application is enhanced. But this can be an expensive if not wasteful way of proceeding—especially now when there is a definite shortage of nickel-bearing alloys of all types. Specially devised, on-the-spot tests can, therefore, be valuable and helpful in choosing.

Exposure should be under the same conditions of temperature (heating and cooling) as the final equipment and to the same series of corrodents.

The 12% Chromium Grades

The 12% chromium stainless steels (actually 11.5—14% chromium) are the "leanest" stainless types in quantity of alloying elements. Hardenable by heat treating, these erosion and wear resistant alloys have fair cold forming characteristics and are satisfactory for hot work or forging. Most are air hardening and must be slowly cooled or annealed after forging to prevent cracking. Both the corrosion resistance and mechanical properties of these steels are directly dependent on the heat treatment accorded them. They have maximum corrosion resistance in the fully hardened condition.

Typical of the 12% chromium stainless formulations is Type 410. Like the other alloys in this series it is not recommended for use where severe corrosion is encountered although it is still very useful for many applications. Keys, cutlery, hardware, machinery parts, and handling equipment for abrasive materials all take advantage of Type 410's excellent mechanical properties and wear resistance. This alloy also offers excellent resistance to scaling at temperatures up to 1200 F and can be used successfully for furnace parts operating below that temperature. However, prolonged exposure at about 900 F results in embrittlement when it is cooled to room temperature.

Other 12% chromium stainless alloys are formulated for a specific set of desirable characteristics. Thus Type 403 is made to special quality requirements for steam turbine buckets.

For parts such as valves, instrument parts, fittings, cams, etc. Type 416, the most readily machinable of all the stainless steels, is used. Type 416 displays the same order of corrosion resistance as the other alloys of the group and has similar mechanical characteristics except for impact strength under severe conditions. The alloy is 85-90% as machinable as Bessemer screw stock (B-1112) while Type 410 is only about 54% as machinable.

All the alloys of the 12% chromium stainless family are weldable. However, sound welds involve the use of special techniques. The high hardenability of these alloys can cause cracking unless the weld is both preheated and postheated. The entire unit should be annealed if possible. Economic considerations usually limit the size of the unit that can be so treated.

For such cases, Type 405 is often specified to take advantage of its non-hardening nature. A low carbon analysis (C=0.08% max) and aluminum retard this alloy's hardening and give welded areas that remain softer and more ductile than those of the other 12% chromium stainless steels.

Stainless Types 440A, 440B, and 440C are also heat treatable. They can attain the highest hardness of any of the stainless steels and have their best corrosion resistance when in the fully hardened condition.

These alloys are especially useful if equipment calls for hardened parts such as bearings, surgical instruments, or specially wear resistant valves. They are more resistant to corrosion than the 12% chromium stainless alloys though slightly less resistant (despite their 16-18% chromium content) than the 17% chromium stainless steels.

The 17% Chromium Grades

The 17% chromium stainless steels show the best combination of corrosion resistance, useful mechanical properties, and good formability of any of the straight chromium types. The increased chromium content makes them much more corrosion and heat resistant than the 12% chromium alloys. They approach, for some applications, chromium-nickel types 301 and 302 in both fabricating ease and corrosion performance. However, this group is not hardenable by heat treatment nor does it respond to cold work to any great extent.

The basic 17% chromium stainless steel is Type 430. Mechanically it is somewhat better than mild steel, and it has better corrosion resistance than Type 410. Type 430 is used in many applications where resistance to scaling at high temperatures is important. Its low coefficient of expansion and high chromium content help retain (under oxidizing conditions) a tight protective scale which remains on the surface of the metal even when the equipment is heated and cooled repeatedly.

Type 430 can be successfully welded, but care must be taken to weld at minimum temperatures for the shortest allowable time. Exposure of Type 430 to welding heat may cause rapid grain growth with subsequent brittleness at weld boundaries and formation of martensite. Under some conditions this appears to increase the alloy's susceptability to corrosive attack.

For assemblies that require a great deal of welded fabrication, however, Type 430T can be specified. Type 430T (sometimes called Type 430Ti) is a nonstandard titanium-containing modification of Type 430 especially produced for its good welding qualities.

If machinability in the 17% chromium stainless corrosion range is of primary importance, then Type 430F is usually specified. A phosphorous, sulfur, or selenium-containing alloy, Type 430F displays machinability characteristics almost equal to those of Type 416 (90-95% Bessemer Screw stock).

There is another non-hardenable chromium stainless steel, Type 446, which finds special application for its high temperature resistance both to scaling and to sulfur-containing flue gases. Its coefficient of expansion is close to that of glass, making it useful for glass molds and metal-glass seals.

The 18:8 Grades

The 18:8 stainless steels (18 chromium, 8% nickel) have long been established in industry. They find uses in storage tanks, shipping containers, conveyors, industrial and household appliances, fasteners, high temperature machinery parts. Their corrosion resistance is so well known that it has become almost a standard of comparison for the performance of other materials.

While some other materials match these alloys in corrosion resistance, few can take the mechanical abuse that the 18:8 stainless steels can. These steels display excellent duc-

tility and toughness over a wide temperature range. They offer great freedom in choice of fabricating methods. This freedom makes possible efficiency, complex designs, light weight, and speedy availability of chemical plant units made of stainless.

The basic alloy of the group is Type 302. This alloy has good corrosion resistance, can be cold worked to high tensile strengths, is non-magnetic when annealed, slightly magnetic when cold worked. It retains its good mechanical properties to very low temperatures.

The addition of silicon to the Type 302 (Type 302B) improves resistance to scaling or oxidation at high temperatures. The silicon (2-3 per cent) has the effect of developing a thin tight scale on the steel when it is heated. Upon cooling this scale does not flake off readily, therefore, no new surface is exposed.

For those parts which require a great deal of machining, a free-machining 18:8 stainless steel has been formulated. Type 303 has a machinability rating equal to 60-70% of Bessemer Screw stock. This compares to a rating of 45% for the other 18:8 stainless steels. Its free cutting qualities aid in chip control, and Type 303 is less likely to gall and seize than other compositions. This combination of non-galling with easy machining characteristics makes it an excellent material for valve or pump parts or for similar equipment in which movable steel surfaces are in contact. Type 303 is slightly less corrosion resistant than Type 302, though the difference is scarcely measurable.

If somewhat more corrosion resistance is desired than is afforded by Type 302, Type 304 can be specified. Type 304 is a rich 18:8. Its chromium and nickel content can be as high as 20-11, though the nominal percentages are 19 and 9. Perhaps more important, the maximum allowable carbon content is limited.

Type 304 is often used where extensive welding must be done in the fabrication of equipment. An ordinary 18:8 stainless with 0.08 to 0.20% carbon, precipitates carbides in the 800-1500 F range. As the metal cools through this range after welding, any protracted delay will affect an area parallel to and adjacent to the weld. This area will be vulnerable to intergranular corrosion along the grain boundaries when subjected later to corrosive media.

Limiting the carbon content to 0.08% maximum in Type 304 increases the time required for harmful carbide precipitation to occur. Welding and cooling Type 304 will not usually reduce corrosion resistance below the requirements of ordinary service.

If heavy plate or sheet stock is to be welded, however, or if the equipment will be operated in the 800-1500 F sensitizing range, it may be desirable to use Type 304L, a 0.03% carbon modification which will reduce carbide precipitation still further.

Types 308, 309, and 310 stainless steels contain more chromium and nickel than the 18:8s. The addition of these alloying elements in greater quantity increases corrosion resistance somewhat, but the same purpose can be served by specifying one of the molybdenum bearing 18:8's. Types 308, 309, and 310 are usually used for their excellent heat and scale resisting qualities.

Type 308 finds wide use as welding rod. The extra nickel lends ductility to the weld and the extra chromium replaces chromium lost through dilution. Thus, good toughness and corrosion resistance at the weld are assured. Occasionally Type 308 is used for welding stainless to carbon steel. Lining of vessels by plug welding stainless steel to carbon steel plate is often done to salvage corroded equipment.

Both Types 309 and 310 possess creep strengths and oxidation resistance superior to Type 302 at temperatures approaching 1900 F and above. However, these alloys should be avoided if high sulfur conditions exist at such temperatures, since sulfur attacks them along the grain boundaries. The straight chromium stainless Type 446 is often recommended for this particular condition.

If equipment must be used in the 800-1500 F sensitizing range or if thick, complicated sections must be welded and kept hot for some time, Type 304 might become vulnerable and give trouble under corrosive conditions. Although Type 304L can be specified, a conventional means of dealing with the problem is to use the stabilized stainless alloys, Types 321 and 347. Type 321 contains titanium and Type 347 contains columbium to control the carbide precipitation. These elements have more affinity for carbon than chromium does. Both alloys are essentially Type 304 stainless so far as their corrosion resistance and mechanical properties are concerned. Type 347 has proved particularly valuable when extremely complex weldments must be made by straight arc welding without a shielding atmosphere.

Molybdenum-Bearing Grades

Generally, the most corrosion-resisting standard stainless steels are the molybdenum-bearing grades. The addition of molybdenum has the specific effect of raising corrosion resistance of 18:8 stainless to such media as sulfurous acid, sulfuric acid, phosphoric acid, and various hot organic acids. Resistance to pitting is substantially bettered. These grades also have the highest creep strengths at elevated temperatures of any of the standard stainless steels.

Type 316, the basic modification, gives useful service at room temperatures in sulfuric acid of concentrations lower than 15% and higher than 85%. As the temperature rises, the corrosion rate also increases, and even Type 316 is not very useful under elevated temperature conditions. However, additions of ferric sulfate, copper sulfate, nitric or chromic acids to the solution will greatly reduce attack and have permitted many economical applications of Type 316.

Where extensive welding is in order, Type 316L, a low carbon modification of Type 316 (Carbon =0.03% max) is available. Type 316L resists harmful carbide precipitation from welding but should not be used if service temperatures are over 800 F.

Even greater corrosion resistance can be obtained if Type 317 is used. This is essentially a modification of Type 316 with increased molybdenum to meet more severe conditions. While useful wherever Type 316 finds application, Type 317 is especially recommended for textile equipment, and the manufacture of inks and pharmaceuticals. It excells in places where freedom from contamination is necessary. At the present time, due to emergency restrictions, Type 317 is not generally available.

There is a non-standard modification of Type 316 which is finding increasing use in particularly severe applications where intricate welding must be performed on heavy plate or where the equipment must operate continuously at sensitizing temperatures. This modification—sometimes called Type 318—contains columbium as a stabilizing component.

Two New Developments in the Fluorocarbon Plastics

***KEL-F DISPERSION COATING** is on inside of this aluminum test dish. After 2.25 hr exposure to boiling concentrated hydrochloric acid, and 5 day exposure to 98% concentrated white fuming nitric acid at 150-170 F, the film shows no corrosion, blisters or fractures.*

A Coating for Aluminum

. . . has excellent adhesion and corrosion resistance.

With all the advantages inherent in the fluorocarbons, their use has been somewhat restricted due to fabrication problems which have been difficult to overcome. One of the main troubles arises from the difficulty in bonding these plastics either to themselves or to other materials. Recently great strides have been taken both in fusion bonding of the fluorocarbons to themselves, and in laminating the plastics to other types of materials.

The Connecticut Hard Rubber Co. has now developed a method whereby aluminum can be covered with a Kel-F coating, the thickness of which ranges from 0.005 in. upwards, the optimum being approximately 0.010 in. The temperature and time combination used in the treatment is such that the physical and chemical properties of neither the aluminum nor the plastic are substantially changed.

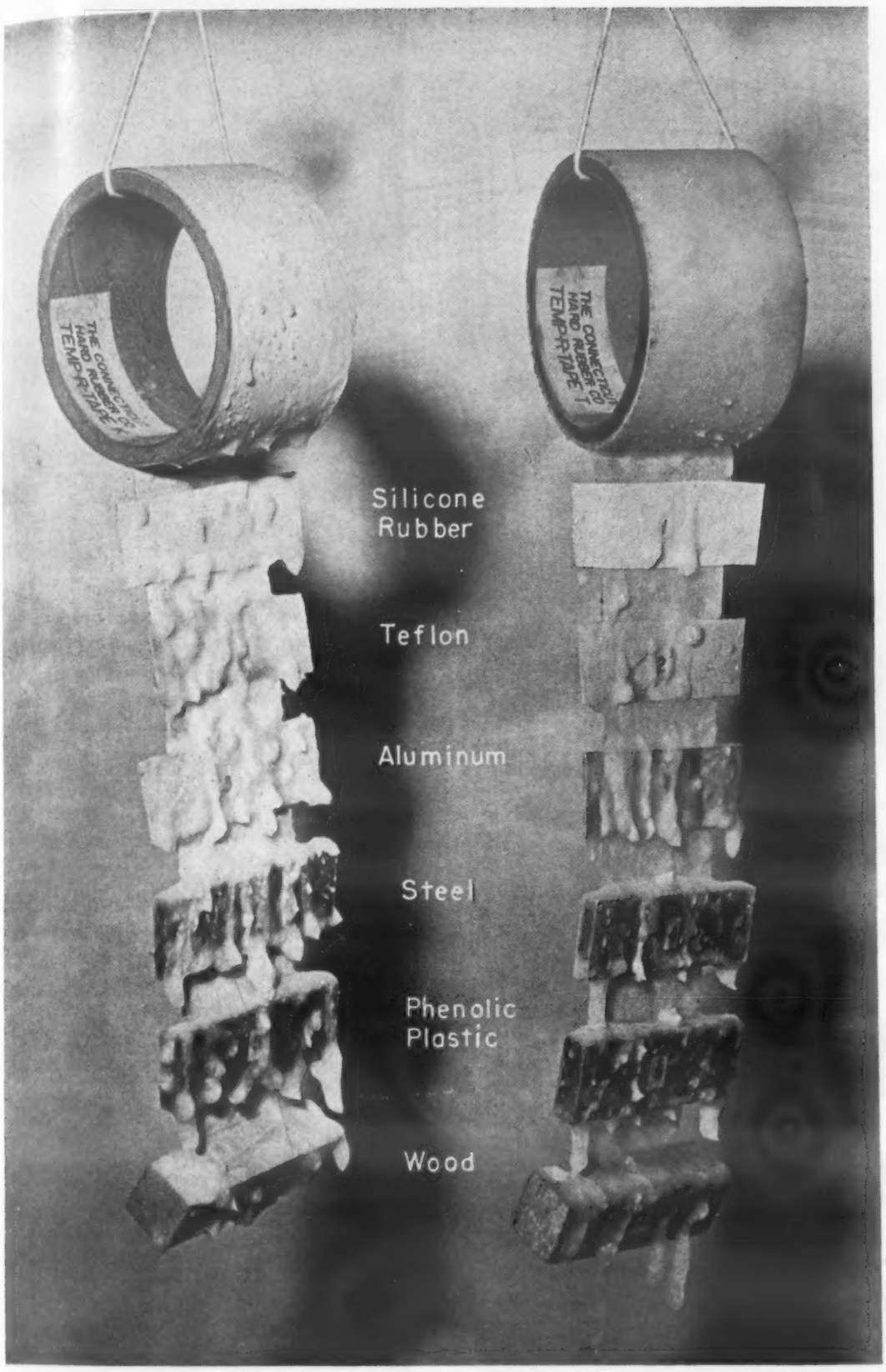
The coating, applied from a dispersion, has no pin holes and is so tightly bonded to the metal that it cannot be peeled or stripped. Tests by the company have shown that lengthy exposure to highly corrosive agents will not blister or lift the film. Due to the good adhesion of the film and the elastic properties of the plastic, the coated metal can be bent and deformed without rupturing or damaging the protective coating. This presents obvious manufacturing advantages in that a sheet of aluminum may be coated first, then drawn or formed to the desired shape.

The process provides the lightweight metal with a coating which possesses all the properties of the plastic which are so important for corrosion resistance applications, namely: retention of properties over temperatures ranging from —320 to 390 F; chemical inertness to most organic solvents, strong acids and caustics, and oxidizing agents; a tensile strength of about 5700 psi; a dielectric constant of 2.8 to 2.3; a dielectric strength of 390 to 5000 volts per mil.

Connecticut Hard Rubber Co. reports that the process is now available to manufacturers on a contract basis at their New Haven plant, where the work will be done. The process is adaptable to parts of all reasonable size and shape, and even tubes of intricate configuration can be successfully coated, inside or out. The company believes the process will also be applicable for steel parts, but as yet research has not been completed.

Developmental work on the process was spurred by the growing need in the liquid-propellant guided missile field for materials, both for storage facilities as well as in the missiles themselves, which would withstand the highly corrosive acids used as fuel. Kel-F coated aluminum possesses approximately the same corrosion resistance properties as glass but eliminates the prohibitive breakage factor. The company foresees a wide application of the process in this field both for the lining of tanks that must store the fluids for an extended period of time, and for those parts of the missiles that are exposed to the fuels.

The high price of the commercial fluorocarbons is limiting, of course, but for selected high service applications, the new process is also expected to find a multitude of uses for compressed gas storage facilities and chemical processing equipment in general.



TWO FLUOROCARBON TAPES, one with Kel-F (left), and the other with Teflon (right), will adhere equally well to almost any material. Sprayed with water at –65 F, the two tapes maintain their adhesion to all types of materials.

A Pressure-Sensitive Tape

. . . retains good adhesive qualities over wide temperature range.

An innovation in the field of fluorocarbons has been announced by The Connecticut Hard Rubber Co. in the form of a pressure sensitive tape made of either Teflon or Kel-F. Tapes and films made of the fluorocarbons have found wide industrial use, particularly in electrical applications due to their excellent insulating properties. Now, however, these materials can be applied like any adhesive tape, yet retain all the advantages inherent in the fluorocarbon materials. This new material will allow manufacturers to apply their own corrosion and solvent resistant coatings to their product at their own plant.

Made possible by the recent development of a silicone adhesive material, the tape consists of a strip of Teflon or Kel-F to which the silicone adhesive is bonded by a special process. The adhesion of the tape to various metal surfaces is about 32 oz per in., and the silicone adhesive remains strong and tacky over a range of temperatures from about 300 F to below —65 F.

According to the company, the process by which the adhesive is bonded to the tape does not adversely affect the fluorocarbon polymer, so the finished tape retains all the basic physical, chemical and electrical properties of the material, unimpaired. The tape can now be obtained in widths up to 24 in.

Uses for the new tape are many and varied; from wrapping ends and splices in Teflon or Kel-F insulated wires and cables, to providing non-adhesive surfaces in containers, on tables, or on the jaws of heat sealing equipment. Small containers can be lined with a single layer of pressure-sensitive fluorocarbon tape, or the adhesive can be applied to shaped or curved fluorocarbon surfaces which can then be pressed to the part, providing a corrosion and solvent resistant film.

A RELATIVELY RECENT addition to the plastics family, the fluorocarbons have been of great interest to manufacturers due to their outstanding properties. Notable among these are their excellent mechanical stability, their high resistance to most corrosive materials, and their high dielectric strength. The combination of these properties makes the materials most desirable for use in the chemical and electrical industries, and many others where insulation and protection against corrosion is an important factor. Commercially the fluorocarbon plastics are produced by E. I. du Pont de Nemours & Co. under the trade name Teflon, by the M. W. Kellogg Co. as Kel-F, and by the Bakelite Co. as Fluorothene.

In this aircraft fuel valve, O-ring is used as static seal in place of gasket.

Long life and reliability are needed by the materials in the O-ring seal in this synchro style torque pressure transmitter made by U. S. Gauge.

Materials For O-Ring Seals

——Their Properties and Selection

Natural and synthetic rubbers, silicone elastomers, and certain plastics meet the exacting requirements demanded in liquid and gas-tight seals.

by E. L. CARLOTTA,

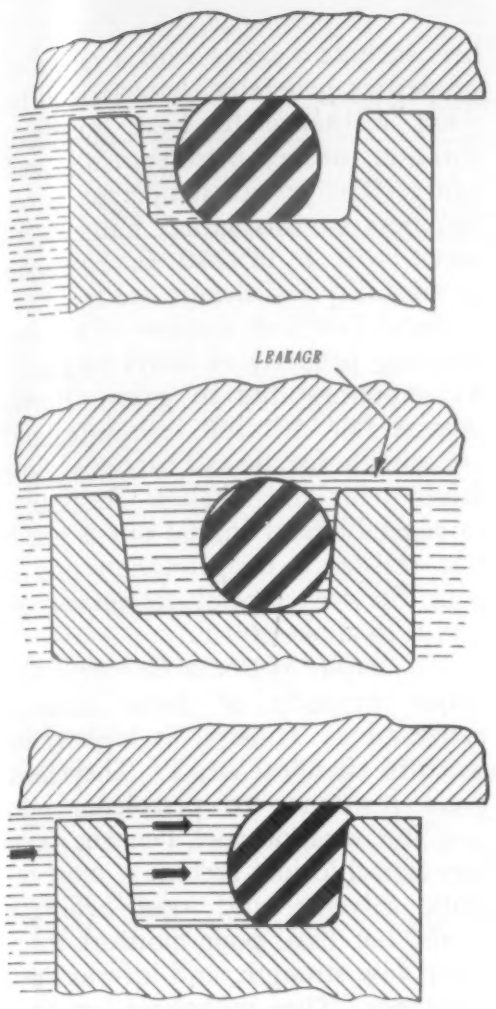
Director of Rubber Research and Development, The Parker Appliance Co.

● IN ORDER TO make the joint between two assemblies liquid or gas tight, it is often necessary to use a seal with enough flexibility to provide effective closure in flexible joints or between slightly mismatched surfaces. Devices such as gaskets, packing and caulking are commonly used as leakproof seals for such assemblies, and a type of gasket coming into broad use is the O-ring. Unlike conventional gaskets, the O-ring does not approximate the shape of the gap to be filled, but is shaped like a doughnut or torus-ring and achieves sealing action by compression, which distorts the ring between the joined members.

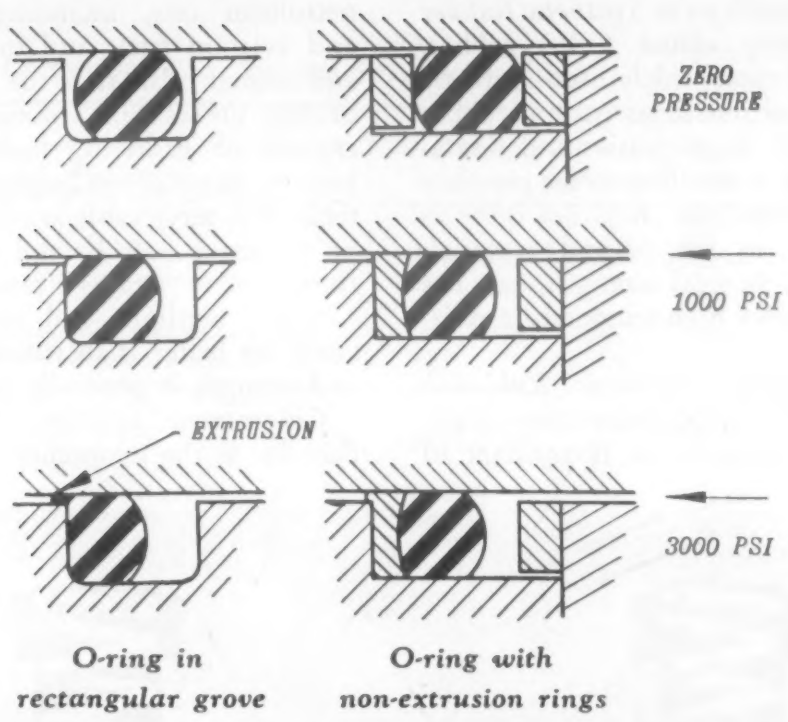
O-rings possess certain advantages over conventional gaskets, particularly in seals involving greater freedom of movement, non-mating surfaces, variations from a flat surface, and latitude in the space between the surfaces. While O-rings are frequently used as simple gaskets for static sealing, they are the most widely used moving or dynamic seal other than simple packing, as they provide an effective barrier during reciprocating, rotary or oscillating motion. Service conditions for moving seals are severe, as pressures in industrial hydraulic systems are of the order of 1500 psi and may go as high as 3000 psi in aircraft.

O-rings in hydraulic systems are lubricated effectively by the fluid in the system, but lubrication must be provided in pneumatic installations. It is of vital importance in moving installations that metal surfaces in contact with the seal be carefully finished to avoid abrading the O-ring material.

The standard form of seat for the O-ring, especially when used as a moving seal, is the rectangular groove. The depth of the groove plus the clearance between members must be slightly less than the cross-sectional diameter of the ring, since the O-ring seals by distortion, and there must be a slight precompression to effect the seal. At no load or very light load, the slight distortion of the ring between the bottom of the groove and the opposing surface seals against the passage of liquids or gases. As



Principle of operation of O-ring seals.



Relative positions of O-ring with and without back-up or non-extrusion rings at increasing pressures.

the pressure increases, the O-ring is squeezed against the opposite side of the groove and is further distorted so that it bears tightly against the bottom and side of the groove and the opposing surface of the other member of the assembly (see accompanying sketches). When O-ring seals are used at pressures above 1500 psi, the rectangular groove may be enlarged and fitted with "back-up" rings of leather, plastics, or similar material to prevent the O-ring from being extruded through the clearance space in the joint.

Material Requirements and Selection

Requirements for materials for O-ring service are exacting. Natural and synthetic rubbers, silicone elastomers, and plastic elastomers meet many of the following prerequisites:

1. Elasticity. The O-ring seals by deformation, so materials with good flexibility are required.

2. Precision forming. The rings must be formed to close tolerances if they are to provide leakproof closures.

3. Resistance to the fluid being sealed. Because of the nature of the service, the material used for the O-ring must be resistant not only to chemical deterioration, but to swelling or dimensional change.

4. Temperature stability. The ring material must retain satisfactory properties over a fairly wide service temperature range, which may extend from about –100 F to 500 F.

5. Adequate strength. Elongation and torsional strength must be sufficient to withstand stretching during installation and service, and twisting during motion of the parts.

6. Resilience. Low permanent set under compression at service temperatures is required to maintain a seal under changing loads or in flexible applications.

The combination of requirements for O-ring service is difficult to fill. Most elastomers have limited resistance to many organic compounds and have a narrow operating temperature range. Maximum properties in every category, however, are not necessary for every application, and many special formulations of molding materials have been developed over the past five years to meet virtually every need. The accompanying table lists a partial selection of various service categories for which such special compounds have been developed by Parker Appliance Co.

An example underscoring the difficulty encountered in matching a sealing material to the fluid handled (as well as with ambient conditions) is the fact that aviation fuels distilled from geographically different crudes may have critically different effects on materials used in fuel system O-rings.

Materials and Characteristics

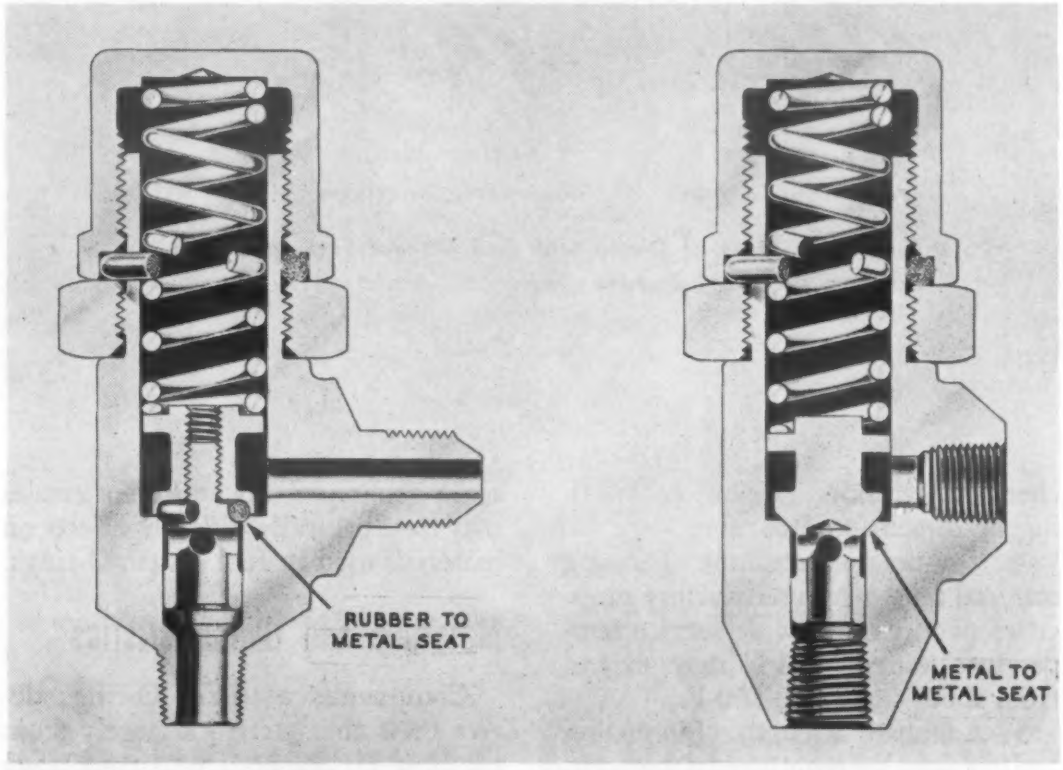
Compounds used for O-rings derive their characteristics largely from the base elastomers from which they are compounded. New materials have led to applications for which O-rings could not have been considered a few years ago. It is now possible, for instance, to handle Freon-type gases in O-ring sealed refrigeration systems.

Natural Rubber — When properly vulcanized, natural rubber has good strength, excellent extensibility, and can be molded to close tolerances. It has good resistance to most chemicals, but has poor resistance to oils in general. Gasoline and aromatic aircraft fuels soften and swell natural rubber and will eventually dissolve it. Natural rubber, of course, softens and swells excessively in petroleum oils, turpentine, carbon disulfide, chloroform, benzene and carbon tetrachloride. Vegetable oils such as castor oil cause moderate swelling. Natural rubber materials have good flexibility at temperatures as low as –65 F, and can be formulated for service at still lower temperatures. Most rubber softens at temperatures above 200 F, but can be formulated to serve at temperatures perhaps a hundred degrees higher.

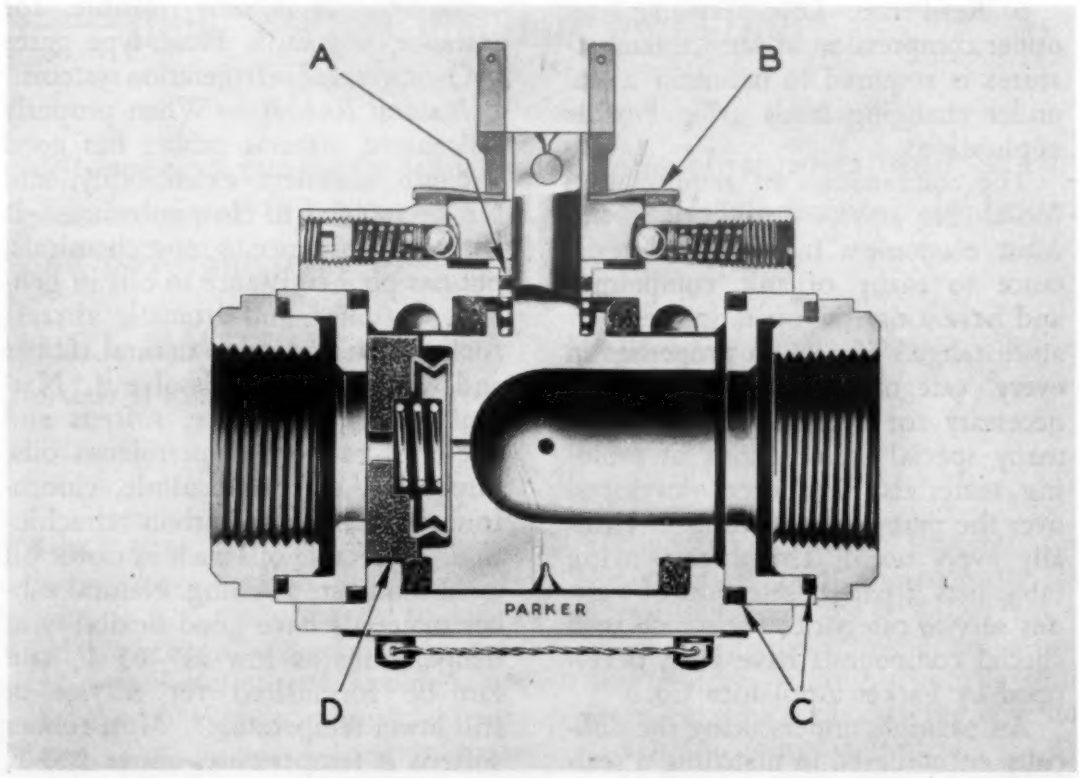
Butadiene-Styrene Synthetic Rubber—Commonly called GR-S rubber, this is the most widely used synthetic rubber, and resembles natural rubber in most of its properties and limitations, such as swelling in the presence of petrochemicals. It is not quite as extensible as the natural material, has lower flexural strength, but has slightly better high-temperature resistance.

Acrylonitrile Synthetic Rubber—This is the rubber sometimes designated as Buna-N. It is resistant to petroleum oils, including gasoline and aviation fuel, and to vegetable and animal oils. It is the most used of the oil-resistant rubbers and is capable of gasketing hydraulic systems or internal combustion fuel systems. It is serviceable at temperatures up to about 350 F, and by proper formulation retains resiliency to –75 F. Sunlight and ozone resistance are better than natural rubber, and strength is generally good.

Chloroprene Synthetic Rubbers—Familiar as the neoprenes, these rubbers include a series with a range of properties generally characterized by good resistance to heat, sunlight, abrasion, ozone, petroleum oils and aging. The service temperatures for members of this group range from about –70 F to 250 F. Strength, extensibility and flexure are fair.



Good strength and wearing characteristics are required of special molding compound for O-rings used in soft seat relief valves (left). Another compound is used for the static cap seal above.



Aircraft fuel system sealing is acid test for special compound synthetic rubber O-rings. Resistance to aromatic fuels and extreme temperature range is required of dynamic seal O-ring at valve stem (A) and of static rings at port adaptor and bottom cap (C).

Butyl Synthetic Rubber—The outstanding property of butyl rubber is its impermeability to gases. Butyls possess fair chemical resistance, and are suitable for use as a barrier against dilute acids and alkalies. Resistance to vegetable and animal oils is good, but resistance to petroleum oils is poor. Service temperatures range from –65 F to about 300 F.

Polysulfide Synthetic Rubber—The major property of these rubbers, marketed as Thiokol, is high resistance to chemical attack. They have good resistance to petroleum oils, gasoline, aviation fuel, benzene (carbon tetrachloride, acetone), most organic solvents, and most hydraulic fluids, but have poor moisture resistance, low strength, and inferior heat resistance. They withstand low temperatures, being serviceable to about –65 F. The upper service temperature limit is about 160 F. Resistance to ozone and sunlight is good.

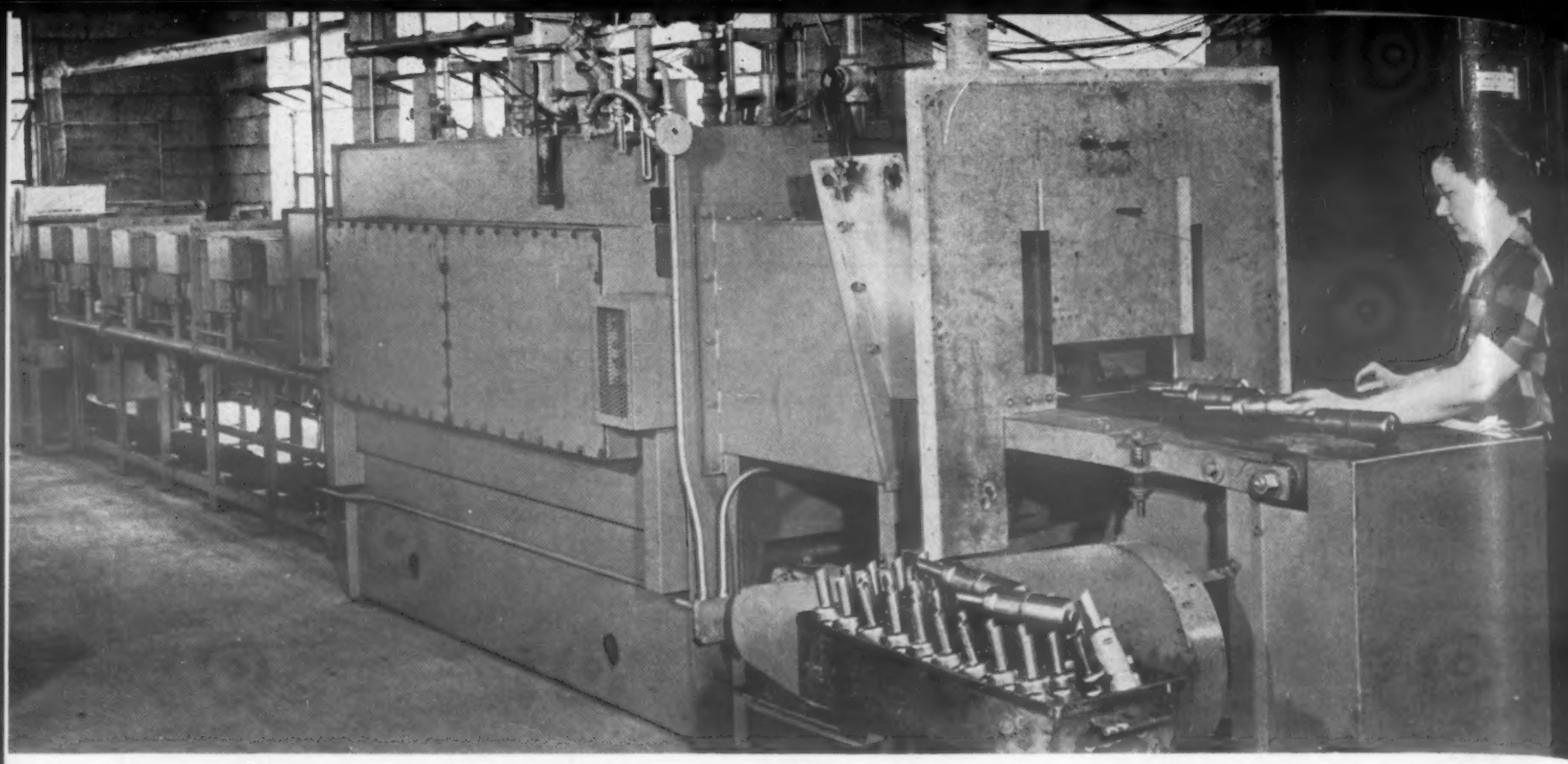
Silicone Elastomers — These are primarily elevated-temperature materials, with a top service temperature of about 525 F. They are also useful for unusually low temperatures, to about –110 F, and because of this are often chosen as a seal against liquid air. Chemical resistance generally is fair, but resistance to petroleum hydrocarbons is poor. Strength properties are poor.

Use of other elastomers has been limited by difficulties in precision fabrication and by the rather poor elastomeric qualities of most of them compared to the natural and synthetic rubbers. When formulated to possess good flexibility, most of the elastomers lose quality because the plasticizer reduces strength, chemical resistance and heat resistance.

Polyethylene plastics have excellent chemical resistance, and can be used without addition of a plasticizer. Some of the fluoro-elastomers, such as Teflon and Kel-F, are valuable materials for simple gasketing, due to their chemical inertness and good resistance to elevated temperatures, and some of the compounded vinyl plastics also provide useful gasketing material, since they possess good strength with a high degree of chemical resistance.

Typical Synthetic Rubber Compounds for Special Service O-Rings

Compound Base	Compound No.	Applicable Specifications	Application	Temp Range, F	Hardness Shore A	Elong, %	Tensile, Psi
AIR AND GAS SERVICE							
Neoprene	601-9	AMS 3242	Air, gas, weather resistance	−40 to +250	80	150	1900
Buna N	392-7	USAF 26613, 11, B	Engine oil, weather resistance	−65 to +200	60	300	1800
Butyl	372-23	—	Hydrogen gas, mild acid and alkali solutions, methyl chloride, lindol, skydrol	−40 to +225	65	500	1600
COOLANT SERVICE							
Buna N	480-1	AMS 3211	Hot ethylene glycol mixtures—(for packing and sealing joints)	−50 to +300	60	300	800
Buna N	PS-20-11	—	High temp. ethylene glycol, alcohols, engine and lubricating oils	−65 to +300	65	350	2135
DRY HEAT SERVICE							
Silicone	467-1	AMS 3305	Air, gasses (static seals)	−100 to +500	80	70	600
Buna N	365-10	AMS 3201	Dry heat (packings, bushings, seals)	−50 to +275	40	300	1200
Neoprene	601-5	AMS 3202	Dry heat (seals, packings)	−40 to +300	60	250	1500
FUEL SERVICE							
Buna N	1009-10	MIL-P-5315 A	MIL-H-3136 fuels—(medium swell, less shrinkage after dry out)	−70 to +212	70	200	1200
Buna N	481-2	AMS 3214	ASTM No. 1 and ASTM No. 2 fuels	−40 to +200	50	400	1400
Buna N	390-3	AMS 3215: AF 26554, 1, D	ASTM No. 1 and ASTM No. 3 fuels—(relatively high swell in aromatic fuels)	−50 to +200	70	275	1300
Buna N	360-1A	—	Diesel fuel oil	−40 to +250	65	275	1214
Buna N	443-2	AMS 7270	Aromatic and non-aromatic fuels, general purpose	−65 to +250	70	265	2030
Buna N	PS-10-13N	MIL-P-5315 A	Aviation gasolines, MIL-H-3136 types 1 and 111, AN-F-58 kerosene	−70 to +160	55	325	1500
HYDRAULIC SERVICE							
Natural Rubber	PS-40-5	—	Ethylene glycol type automotive brake fluids	−50 to +250	70	300	2600
Buna N	PS-20-5	J.I.C. hydraulic standards	SAE oils 10, 20, 30; automotive brake fluids; water; air (general purpose compound)	−60 to +250	70	300	2300
Buna N	145-140	MIL-G-5510	Hydraulic fluid MIL-O-5606; alcohol mixtures; water; air silicone oils	−65 to +225	90	100	1340
GR-S	255-5	—	Brake fluids, SAE-R-70 or MIL-F-2111, non-mineral oil service	−40 to +250	70	220	2100
LOW TEMPERATURE SERVICE							
Neoprene	581-1	—	Petroleum base lubricants	−85 to +275	60	350	2000
Neoprene	601-10	AMS 3205	With lubricating oils	−75 to +215	50	400	1500
Silicone	467-1	AMS 3305	With many solvents and chemicals; air; oil; water; gases	−100 to +500	80	70	600
LUBRICATING AND ENGINE OIL SERVICE							
Buna N	323-1	AMS 3227	Hot oils 40, 50, 60; AN-VVO-46; alcohol; coolants—(low swell compound)	−50 to +300	60	300	1500
Buna N	430-1	AMS 3228	Hot oils; coolants	−50 to +300	70	250	1500
Buna N	367-11	AMS 3229	Oil resistant applications—(low swell compound)	−40 to +225	80	170	1500
Buna N	435-2	AMS 3220	Greases; fuel oil; AN-F-42 type 1 fuel; gasoline; kerosene; water	−40 to +325	60	400	2200
Neoprene	601-4	AMS 3222	Hot petroleum base oils (high swell compound)	−50 to +300	50	400	1500
WEATHER RESISTANT SERVICE							
Neoprene	601-1	AMS 3240	Weather resistant	−40 to +250	40	350	900
Neoprene	601-8	AMS 3241	Weather resistant (chloroprene type)	−50 to +250	60	250	1500
Neoprene	601-11	AMS 3209	Weather resistant and sunlight resistant	−50 to +200	70	200	1700
MISCELLANEOUS SERVICE							
Neoprene	614-1	—	Excellent resistance to Freon 12, 22, and paint solvents	−65 to +275	70	250	2000
Buna N	284-9	—	Applications in food and beverage industries	−50 to +300	70	160	2140
Buna N	187-4E	—	Hot oils, coolants (graphited rubber compound)	−40 to +325	70	345	2040
Silicone Type	Parkone 1, 2, 3, 4, 5	—	Most dilute and some concentrated acids; oils; solvents; alkali solutions	−100 to +500	40 to 80	400 at 50 durometer	800 at 50 durometer
Thiokol	147-64	—	Aromatic and non-aromatic fuels—(low swell); oils; solvents	−40 to +200	65	250	1000
Neoprene	597-1	—	Applications requiring soft rubber	−65 to +225	40	815	2020
Buna N	621-1	—	Rotary seals—(low friction; high abrasion resistance)	−50 to +275	80	220	1650



Furnace brazing steel units to form small motor mufflers.

Copper and Silver Brazing Simplify

Combination of proper brazing techniques and simple shapes 1) improves efficiency in production of small, complicated parts and 2) permits use of dissimilar metals.

● IN THE DESIGN of fabricated parts, the continual trend is toward simplification in order to reduce the overall manufacturing costs. In line with this trend, there is a growing recognition of the advantages to be gained by breaking up small, difficult-to-fabricate assemblies into simple components that lend themselves to stamping, casting, forging, or to straight screw machine operations, then combining the pieces into a composite assembly by welding or brazing. This method offers another economic advantage: when certain sections of a piece should be made of a metal possessing some properties not required in the whole, these sections can be made of a suitable metal, and joined to the other parts made of a less costly metal.

For this type of operation brazing has the advantage over most other assembly methods of being well suited to mass production techniques. After the joining metal has been placed on the parts they are usually stacked in trays or baskets to be carried through the furnace. Since the use of fixtures to hold the parts during brazing is costly and time consuming, where a press fit is impossible a small spot weld or a rivet may be used to hold the pieces. The joining of the parts is accomplished by the melting of the filler metal as it comes up to furnace temperature and the subsequent solidification as it cools. By passing the baskets of work-pieces through a continuous furnace the production rate can be very high. The end result is a one-piece assembly which is strong, leakproof, and will withstand relatively high pressures.

Copper Brazing

Two filler metals used commonly by the Huber Metal Processing Co. are copper and silver brazing alloys. Most of the copper brazing is done in controlled atmosphere furnaces which reduce scaling of the metal at the 2050 F temperature used for copper brazing. In rare instances copper induction brazing is used, but the induction heating technique is mainly limited to brazing with the silver alloys. The standard atmosphere used is a reacted natural gas of about 40% hydrogen, with some carbon monoxide and the remainder nitrogen, though for copper brazing of stainless steel, a pure hydrogen gas is used.

Since copper has a low surface tension at brazing temperatures, the best bonds are made with a close fitting joint, such as that obtained in a press fit. The strength of the bond may be improved by telescoping the joints. This will increase the overlap and if enough copper is provided the overlap will be completely filled. In case of an open fit, where the pure copper filler will not close over, a copper paste with a small amount of iron powder added to improve the viscosity should be used.

There is a variety of techniques for applying the copper filler metal to the joint, depending on the individual job. When, due to the method of assembly, there is no room to place the filler metal between the faying surfaces of a joint, copper paste applied at the edge of the joint will flow into the seam by capillary action; or sometimes it is desirable to place the copper a short distance from the joint. For example, when joining two pieces of greatly unequal mass, the smaller one will heat much faster than the larger, the copper will melt before both parts have reached furnace heat, and a poor bond may result. Placing the copper a short distance from the seam delays the application of the filler metal until both parts reach the proper temperature.

The copper brazing metal is available in several forms: wire in a range of sizes, sheet stock in a variety of

gages, or paste. The wire may be bent into rings for circular type applications. The sheet or foil can be die cut into the exact shapes required, then fitted neatly around the contacting surfaces. Bits of sheet are also useful to place at contact points in asymmetrical joints. The prepared paste which contains the metal or an oxide of the metal is used mainly where it is required to flow into a crevice in a press fit, or where the bonding material must be placed on the underside of the work surface. Also, since it is difficult to handle small pieces of wire or sheet without loss, the paste is useful where tiny joints require small amounts of the brazing metal.

Silver Brazing

There are applications where silver induction brazing is more economical or must be used due to the particular requirements of a certain job. The configuration of some parts is such that if they were put in a furnace, warpage would occur. This can be avoided by induction heating since in this process the heat is localized to the joining sections of the parts. In addition, pieces difficult to position in the furnace may be induction brazed, and multiple fixtures should be used to gain the full production potential of the heating machine.

Silver brazing can be done in much the same way as copper brazing, though it lends itself particularly well to induction heating. The material is available in a range of alloys with melting point temperatures of 300 to 1900 F, allowing the manufacturer to silver braze over a piece that has been copper brazed in a previous operation, without softening the copper bond. Due to the greater stiffness of the silver alloy at brazing temperatures, the metal makes a more satisfactory joint than copper in cases where the seam is relatively open.

by **L. F. KLEIN**, Vice President & General Manager, Huber Metal Processing Co.

Joining of Complicated Parts

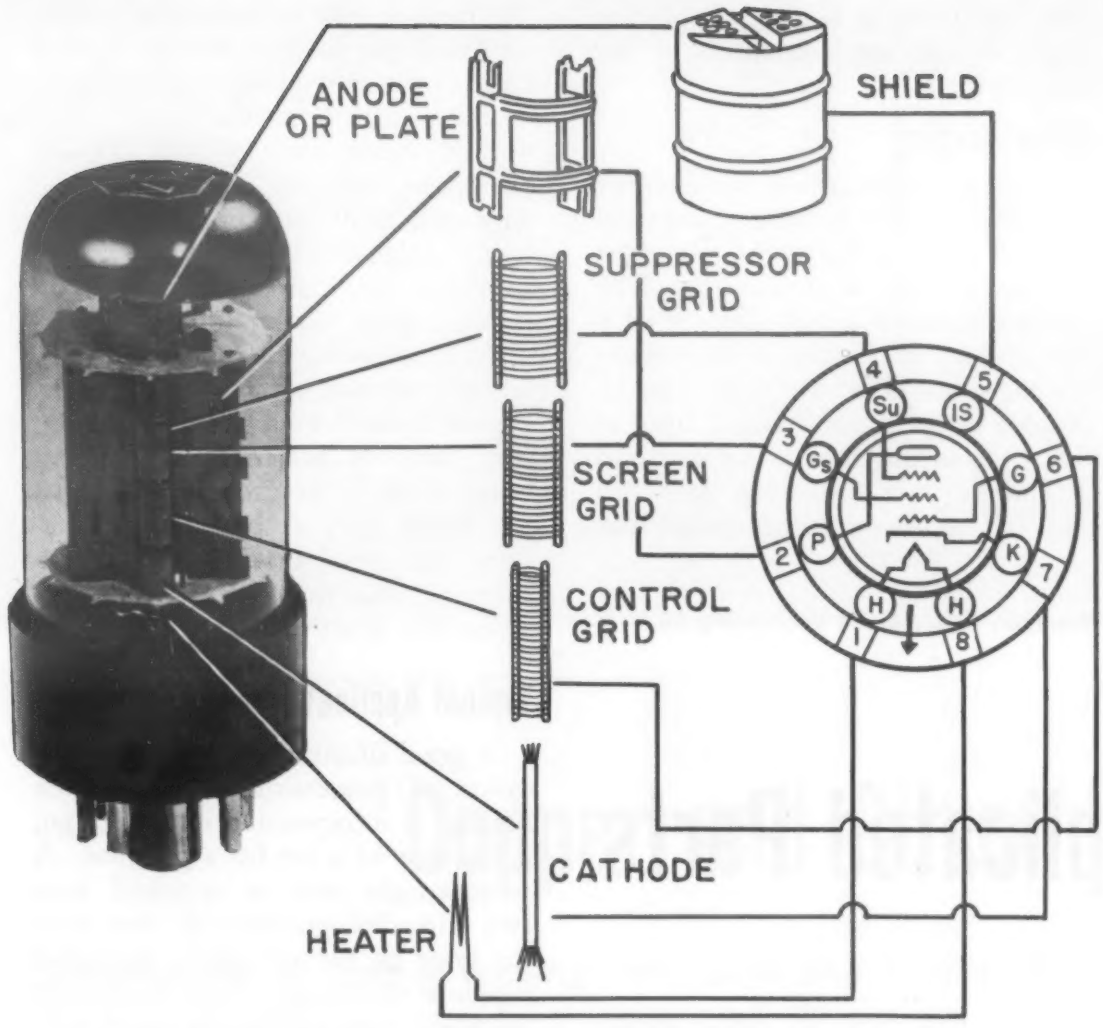
Gas appliances are prepared for the furnace by the addition of copper paste.

Typical Applications

A good illustration of the simplification of processing possible when brazing is incorporated into a design, is the case of a tee for a gas line. A presure-tight unit is required with two threaded portions in line with the body of the tee, and a threaded nipple at right angles to it. By making the body, with the two threaded portions, and the right angle threaded nipple separately on a screw machine, then brazing the two pieces together, a high production rate can be achieved with standard tooling.

Another example is a tractor pitman arm, produced as a pair of stampings, then brazed together. The stampings are made of SAE 1020 steel. However, a bearing at one end of the arm requires a hardness of 42 Rockwell C which is unobtainable with the 1020 steel. A small bushing of SAE 1035 steel which can be brought to the desired hardness is made, then brazed to the end of the arm. The entire assembly is joined with six simultaneously copper-brazed joints.

Even pieces of simple form can sometimes be adapted to copper brazing with a substanial saving in cost. A knurled head screw could have been made by machining down a piece of bar stock and threading the barrel thus formed. It is more economical, however, to knurl a piece of bar stock for the head, drill to form the barrel, and cut off to length. A piece of smaller diameter is then threaded for the barrel, fitted into the drilled hole in the knurled head, and the two are copper brazed together. Both pieces thus became simple screw machine jobs with a minimum of metal removed.



Electronic tube is an outstanding example of application of materials to vacuum service.

High Temperature Materials for Vacuum Service

Special properties required of materials for service in a vacuum include low vapor pressure, stability, low gas permeability and ease of outgassing.

by HERBERT B. MICHAELSON,
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● MATERIALS FOR USE in vacuum at high temperatures—whether in electron tubes or in vacuum furnaces—must have special characteristics not ordinarily needed for operation in air or other gaseous atmospheres. Materials for electron tubes have been fairly well standardized in mass production by engineering developments of the past half-century. The field of high vacuum melting and heat treating, on the other hand, has been confined largely to experimental and small-scale processes, and the choice of structural materials for vacuum furnaces has been a specialized problem. Since improvements in vacuum techniques in recent years have encouraged wider industrial applications in the melting, casting, annealing, brazing, sintering and purification of metals, the problem of furnace materials is broadening. The requirements unique to vacuum service include the following:

Low vapor pressure—If either metallic or non-metallic structural parts in a furnace are volatile at operating temperature, part of the vapor is carried away by the vacuum pumps and the rest gradually condenses on the surfaces in the cooler zones with resultant contamination of those surfaces. Conducting metallic vapors may also short circuit the electrical system of a furnace. In electron tubes, volatile impurities in an oxide-coated cathode, for example, may ultimately condense on grids or insulation causing undesirable surface contamination.

Stability in Vacuum—Contact reactions sometimes proceed much faster in high vacuum than in air or protective atmospheres. One example is the reduction of oxide refractories by graphite at elevated temperatures. Another is the reaction between two different furnace refractories to form a low-melting compound. In addition, furnace refractories tend to decompose more readily in high vacuum because of their dissociation pressures. In vacuum tubes, the decomposition of thin oxide films on grids and anodes can "poison" an oxide-coated cathode with oxygen or metallic vapors.

Ease of outgassing—In electron tubes, rapid outgassing of parts is obviously desirable. In vacuum furnaces, excessive gas evolution from crucibles, insulating tubes, or other components could contaminate the metal being melted or heat treated and would also increase the required pumping capacity. This is especially true in the high vacuum region below one micron pressure (10^{-3}mm of mercury).

Low gas permeability—The walls of any kind of vacuum chamber are usually of dense material, free from porosity and resultant leakage. For this reason, rolled steel sheet is preferred to castings or, in experimental furnaces, fused quartz or pyrex glass instead of porous ceramics. An important limitation of non-porous ceramic furnace tubes is their tendency to develop higher gas permeabilities at very high temperatures.

Gettering properties—Certain metals such as zirconium, barium, and tantalum are used in vacuum tubes to absorb or combine with residual gases.

Vacuum Tube Materials

In the electron tube industry, various materials are used at operating

temperatures of 400 to 4100 F in vacuums of the order of 10^{-8} mm of mercury. Anodes for low-power receiving tubes are usually made of high-purity nickel, carbonized nickel, aluminized steel, or Carbostrip (a carbonized nickel-plated steel). Nickel is easily fabricated but is relatively expensive. Although steel anodes are more economical, they are more difficult to outgas and require careful control of processing. Aluminized steel, because of ease of fabrication, has found increasing use in recent years as an alternative for the more costly nickel. In high power receiving and transmitting tubes, where the anode may operate at temperatures as high as 1830 F, materials of very low vapor pressure and high melting point are used, including graphite, molybdenum, and tantalum. Graphite is a good heat radiator but needs extensive outgassing. Tantalum has a high melting point and acts as a getter, but requires very careful processing and special exhaust technique. Molybdenum finds wide use, but is comparatively difficult to weld and fabricate.

Although grids may operate in the range 200 to 750 F, they must be able to withstand temperatures as high as 1830 F for short periods on high frequency induction heating during tube processing and exhaust. On low-power tubes, the No. 1 grid is frequently an alloy of nickel and manganese because this is a poor emitter of primary and secondary electrons. The No. 2 and No. 3 grids can be molybdenum or one of its less expensive alloys such as molybdenum-iron or nickel-molybdenum-iron. Other common grid materials include nickel and nickel-chromium-iron.

High-power tubes usually employ molybdenum which may be clad with zirconium, platinum, gold or silver. These cladding materials are generally considered to decrease electron emission from the grid and to prevent the formation of molybdenum oxides that sometimes form on unclad grid laterals during sealing operations. These oxides may decompose and "poison" the cathode. Other grid lateral materials are tantalum, tungsten, tungsten-molybdenum, and platinum. The grid supporting siderods may be of nickel, steel or Pliron (nickel-plated iron or steel). Siderods for No. 1 grids can be made of a copper alloy of good heat conductivity to reduce grid temperature and grid emission. In transmitting tubes, molybdenum siderods are used, especially when the grid lateral wires are molybdenum.

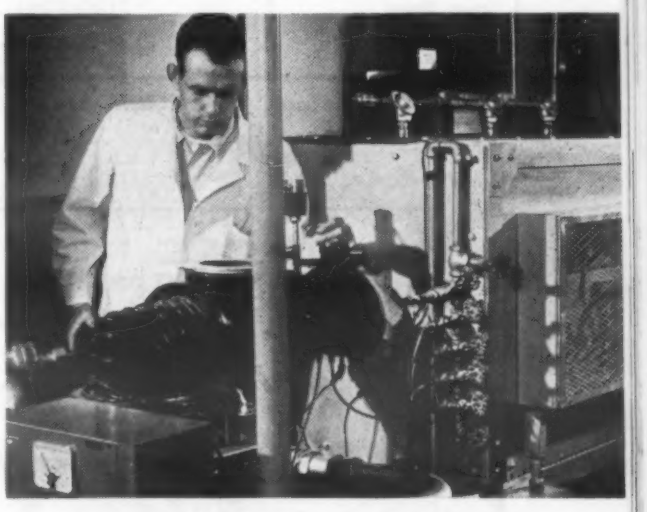
Among the materials commonly used for vacuum-tight sealing to glass in electron tubes are Kovar and Fernico for hard glasses and Sylvania No. 4 alloy for soft glasses. In power tubes and x-ray tubes, a nickel-clad copper lead-in material known as Kulgrid is commonly employed and is available either in stranded or single wires. Kulgrid welds to itself, nickel or copper, and can be welded to tungsten or molybdenum.

Electron emitters in vacuum tubes operate in a wide range of temperatures. Large transmitting tubes may utilize pure tungsten filaments operating as high as 4100 F. Higher electron emission efficiency could be obtained above this temperature but the evaporation rate becomes excessive. Thoriated tungsten, a more efficient emitter, operates at 2725 to 3275 F, but is ordinarily used only if the maximum plate dissipation is below 1000 watts or the maximum plate voltage is less than 4000 volts. In lower power tubes, filaments or indirectly heated cathodes run at 1300 to 1650 F and are usually coated with a mixture of barium, strontium and calcium oxides. The base metal for filaments can be pure nickel or nickel alloyed with aluminum, cobalt, silicon, or titanium. Tungsten has also been used. Cathode sleeves are usually made of "A" nickel. In indirectly heated cathodes, the heater wire is usually of tungsten and operates in the range 1825 to 2375 F. The heater insulation coating is generally alumina, although magnesia and beryllia have found occasional use.

Getters are used in vacuum tubes to shorten the exhaust period during tube processing, at about 750 F, and to maintain high vacuum throughout tube life. Flash getters are used in the form of pellets, strips or wires, and are usually evaporated by induction heating during tube exhaust. Before and during condensation on the tube walls, the getter vapor adsorbs or combines with gaseous residues. Later, at a typical operating temperature of 300 to 400 F, the getter mirror formed on the tube walls traps gases liberated by various parts during tube life. At this temperature the getter should have a vapor pressure no higher than 10^{-7} mm of mercury. "Flash" getters usually have barium or a barium alloy as the active ingredient and are heated to the evaporation temperature by high frequency induction or by electron bombardment. Bulk getters are sheets or wires of zirconium, titanium, tantalum or columbium mounted on a hot electrode of the tube. This type of getter is maintained at 900 to 2200 F. during tube operation, depending on its optimum gas-absorption temperature. Non-volatile powders of zirconium, thorium, thorium alloys, or tantalum can be sintered to anodes for continuous operation as coating getters in the range 400 to 2200 F. Operating characteristics of various getters are shown in a table.

Furnace Materials

Induction, resistance, arc, and gas-



Reactive metals such as titanium or zirconium can be annealed in vacuum furnaces of this type.

Properties of Bulk & Coating Getters

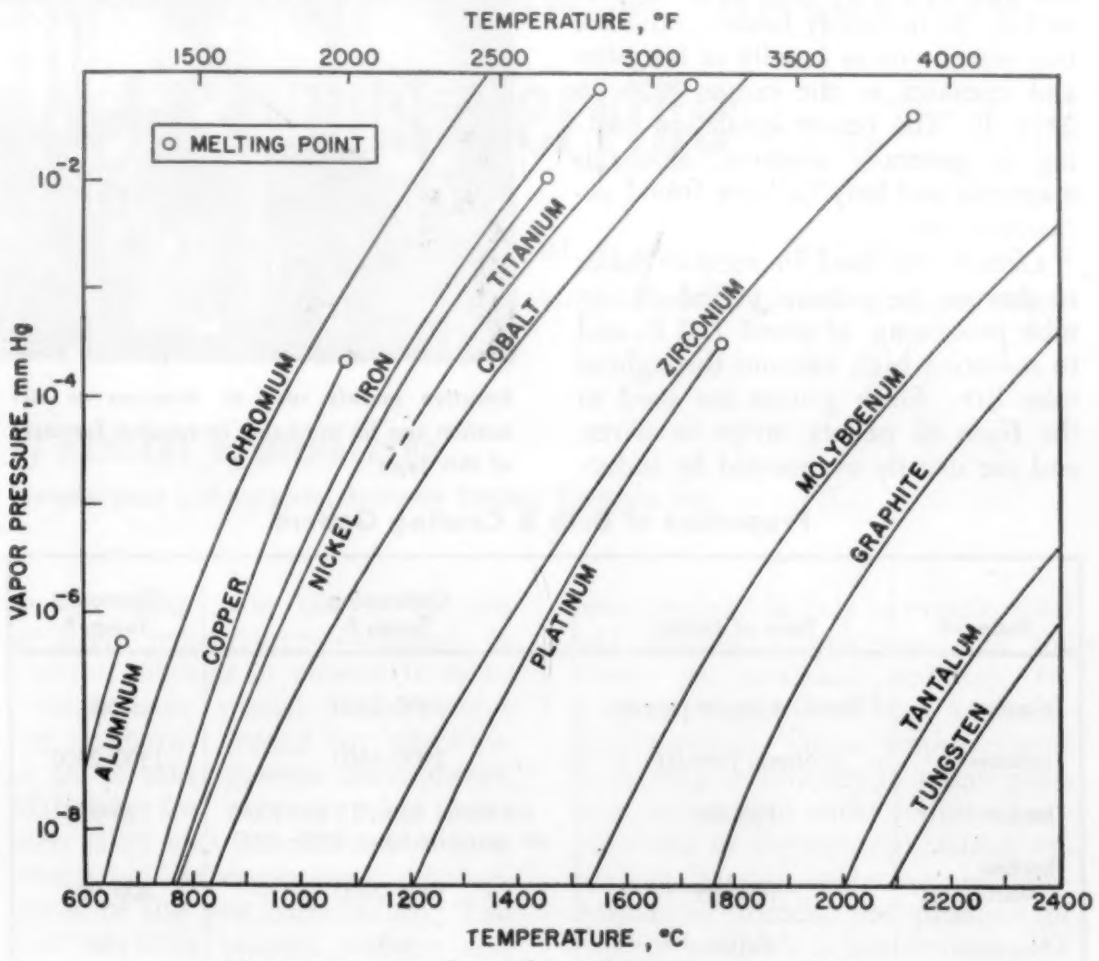
Material	Form of Getter	Outgassing Temp, F	Operating Temp, F
Zirconium	Sheet, wire, or powder	1300–2350	1500
Tantalum	Sheet, powder	2900–3600	1300–2200
Thorium	Powder	on metal base, 1500–1800 on graphite base, 2700–2900	750–925
Thorium-Mischmetal	Powder	1475–2200	400–900
Columbium	Pellets	3000	900

Properties of Non-Metallic Materials

(All properties depend on impurities and fabrication method)

Material	Melting Point, F	Max Operating Temp in High Vacuum, F	Coef of Ther Exp Per °F	Thermal Cond Btu/Hr/Sq Ft/Ft/°F	Thermal Shock Resistance	Hardness Mohs' Scale	Vapor Pressure		Elect Resistivity at 2200 F, ohm-cm	Load Bearing at 2200 F
							mm of Hg	Temp F		
Alumina, fused	3722	3270	4.5×10^{-6} (68–2300F)	0.4–0.5	Excellent	9	0.35	3720	10^{4}	Good
Beryllia, fused	4568	3630	$5.1–5.2 \times 10^{-6}$ (68–2550F)	1.1–2.1	Excellent	9	1.8×10^{-3}	3775	10^{12}	Good
Graphite		4530	4.3×10^{-6} (77–104F)	4.4–14.4	Excellent	0.5–1.0	10^{-6}	3630	7.9×10^{-4}	Excellent
Magnesia	5072	2910	$7.9–8.3 \times 10^{-6}$ (68–3100F)	0.4–0.8	Poor	6	High	>3630	5×10^{-11}	Fused, good; sintered, poor
Mullite	3250–3335	2730–3090	$2.5–2.9 \times 10^{-6}$ (68–2600F)	0.2–0.3	Good	6				Excellent
Sillimanite	2950[a]	2550–2730			Good	6–7				Good
Silica, fused	3110	2010[b]	0.3×10^{-6} (68–2280F)	0.2–0.35	Excellent	5–7	9.9×10^{-6}	1830	5×10^{5}	Fair
Thoria, fused	5486	4900	$5.2–5.3 \times 10^{-6}$ (68–2550F)	Very low	Poor	7	3×10^{-2}	4710	10^{10}	
Zircon	4622	3090[c]	$2.0–3.7 \times 10^{-6}$ (68–1475F)	0.2–0.3	Good	8			10^{4}	Good
Zirconia, Stabilized	4600–4700	3990	$2.8–6.0 \times 10^{-6}$ (68–2275F)	0.36	Fair to good	8.5				Good
Silicon Carbide	>4900	3990[c]	$2.5–2.6 \times 10^{-6}$ (32–3090F)	1.1–2.4	Good	9–10			2.5	Excellent
Lava, fired		2190–2280	$5.8–6.4 \times 10^{-6}$ (77–2900F)			6			10^{4}	Good

NOTES: [a] *Decomposes.* [b] *Devitrifies.* [c] *Dissociates.*



Vapor pressures of metals used in vacuum service.

fired furnaces are used for vacuum melting and various kinds of heat treating. Induction or resistance heating can be used either inside or outside the vacuum chamber, arc heating inside, and gas firing outside.

The induction furnace is used for melting high-melting-point metals, for annealing, sintering, degassing, and brazing. Materials for fabrication into melting crucibles are selected with particular regard for reaction with the metal to be melted. Crucibles for small melts are usually made of alumina, magnesia, beryllia, sillimanite, quartz, thoria, zircon, stabilized zirconia, or graphite. Ceramic liners such as sintered magnesite, electrically fused magnesia or sintered corundum are sometimes used inside graphite crucibles to prevent carbon pickup by the melt. Plastic refractory clays have also been employed.

Commercially available induction furnaces can process molten metals at temperatures up to about 3200 F, the upper limit of the refractories

Properties of Metals and Alloys

Materials	Melting Point, F	Coef of Ther Exp per °F	Thermal Cond, Btu/Hr/Sq Ft/Ft/°F	Brinell Hardness	Out-gassing Temp, F	Vaporization Rate at 7.6 mm Hg		Creep Strength (stress for 1% creep in 10,000 hr)	
						Temp, F	g/cm²/sec	Psi	Temp, F
Oxygen-free copper	1981	9.3×10^{-6}	224	100[a], 42[b]	925–1475	1735	1.33×10^{-7}		
Hastelloy C	2320–2380	6.3×10^{-6}	7.2	195[c], 185[b]	1650				
Iron, ingot	2795	6.8×10^{-6}	39	90[e], 67[b]	1800	2000	1.29×10^{-7}		
Inconel (wrought)	2540–2600	6.4×10^{-6}	8.7	150[b], 180[e], 260[a]	1650			22,000 600	900 1800
Inconel X	2540–2600	7.6×10^{-6}	8.5	200[b]	1650			60,000 18,000	1200 1500
Nickel	2650	7.4×10^{-6}	48	100–200[b]	1400–1740	2115	1.18×10^{-7}	10,000	750
Nichrome V	2550	9.8×10^{-6}	7.8	85–90[b]	1700–3200			350[f]	2000
Molybdenum	4757	2.8×10^{-6}	84	200–230[g]		3490	1.29×10^{-7}	970[h] 900[h]	1635 1760
Stainless steel (310)	2540–2650	8.0×10^{-6}	7.8	165[b]				4,500 1,000	1500 2000
Stainless steel (316)	2500–2540	8.9×10^{-6}	9.4	165[b], 275[a]				24,000 2,000	1000 1500
Stainless steel (347)	2540–2600	9.3×10^{-6}	9.3	160[b], 300[a]				19,000 1,000	1000 1500
Tantalum	5425	3.6×10^{-6}	31	55[b], 125[a]	3300–3600	4365	1.55×10^{-7}		
Tungsten	6152	2.2×10^{-6}	92	350[i]	3300–4200	4630	1.47×10^{-7}		

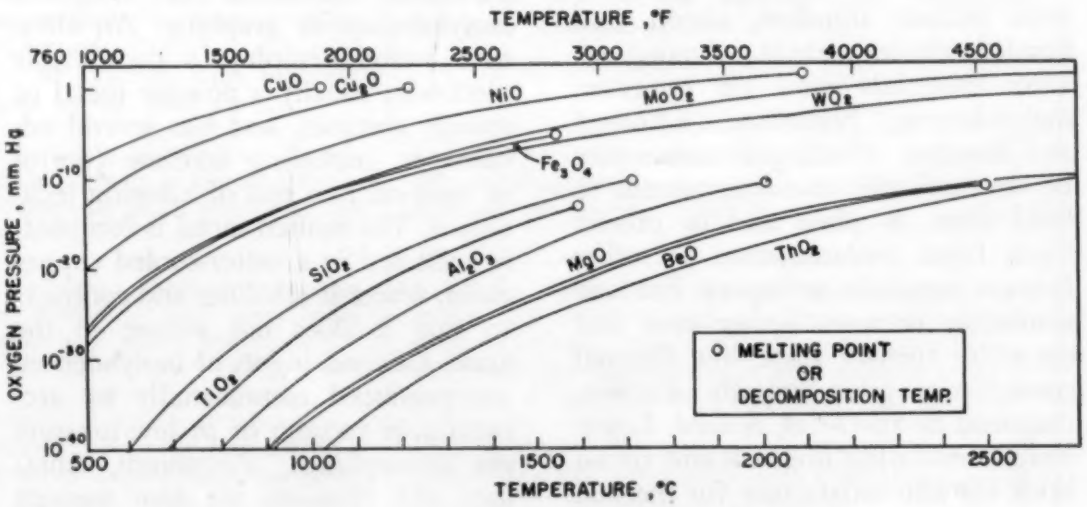
NOTES:
[a] *Cold-rolled.* [b] *Annealed.* [c] *Cast.* [d] *Rolled.* [e] *Hot-rolled.* [f] *1000 hr.* [g] *Forged.* [h] *100 hr.* [i] *Swaged.*

used. Some furnace assemblies with lampblack insulation, however, have been reported to operate up to 4500 F. Ceramic furnace tubes for induction furnaces should have a high melting point, must be vacuum tight in the range of about one micron of mercury at operating temperature, and should have a low vapor pressure and low dissociation pressure; in addition, furnace tubes should have stable crystal structure in the range of operating temperatures. Fused quartz, mullite, alundum, zircon and sillimanite are used as vacuum-tight furnace tubes. For service above about 2500 F, pure alumina, magnesia or stabilized zirconia, free from the lower melting ingredients of glass-bonded refractories, can be used in small furnaces. Even pure oxide refractories, however, do not always remain vacuum-tight above 2500 F.

In the type of induction furnaces employed for vacuum melting and casting, watercooled copper molds are frequently used. Sand molds and other ceramic molds often require extended outgassing. Ceramic liners, however, have been used successfully in graphite molds to produce sound castings. When an induction furnace is housed in a metal tank, eddy currents and hysteresis in the tank wall are power losses. These can be reduced by selecting a non-magnetic metal such as austenitic stainless steels for the tank shells.

Externally-heated resistance furnaces are used up to about 2500 F for vacuum melting, casting, degassing, sintering and annealing. In small furnaces where a self-supporting tungsten or molybdenum heater is used inside the vacuum enclosure, extremely high temperatures can be obtained. When the heating element is in contact with ceramic supports, the upper range of furnace operation is generally limited to 2700 F. Globars are also commonly used heating elements.

The smaller types of electric fur-



Dissociation pressures of various oxides used in vacuum service.

Materials for Use below 2200 F

Material	General Characteristics	Applications
Aluminized Steel	Low carbon steel coated with alloy of 8% silicon-aluminum blackened to 85% black body radiation by heating in hydrogen or vacuum above 1100 F.	Alternate for carbonized nickel in low power electron tube anodes.
Oxygen-free Copper	High electrical and thermal conductivity. Because of low melting point and high vapor pressure, copper anodes require forced-air or water cooling.	Housekeeper featheredge seals in transmitting tubes, x-ray tubes, magnetrons and klystons. Water-cooled casting molds in vacuum furnaces.
Columbium	Getter properties similar to tantalum but extend to lower temperatures.	For gettering in electron tubes; oxide-free columbium pellets supported by molybdenum wire.
Inconel	Good high strength, corrosion resistant, freedom from intergranular deterioration at high temp.	For service to 2000 F.
Inconel X	Age-hardenable, high creep strength 1200-1475 F. Oxidation resistance less than Inconel above 1475 F.	Used for springs up to 1000 F.
Nickel-chromium	60% nickel—16% chromium—balance iron useful to 1700 F; 80% nickel—20% chromium to 2000 F.	Heating elements: the 80-20 alloy also used as furnace tube for operation to 1800 F.
Nickel	Low vapor pressure, easily outgassed, good corrosion resistance. To increase radiation coefficient, nickel can be carbonized.	Major materials in vacuum tube industry, for anodes, oxide-coated cathode sleeves and filaments, structural parts. Radiation shield in furnaces.
Quartz	Non-porous, low coefficient of thermal expansion, good resistance to thermal shock, high electrical resistivity. Reduced by carbon at high temperatures. Devitrification starts at about 1925 F.	In vacuum furnaces as tubes, muffles, crucibles and investment molds. In some vacuum tubes as electrical insulation.
Vycor	Similar to quartz.	Vacuum furnace tubes and crucibles.
Stainless Steels	Austenitic stainless non-magnetic, not appreciably affected by induction heating, low thermal conductivity and gas permeability.	Used for shells of induction furnaces, radiation shields, baffles, ingot molds.
Mild Steel	Carbon or low alloy steels.	Retorts in vacuum furnaces for service below 1475 F, radiation shields and baffles.
Thorium	Pure powdered thorium or 80% thorium—20% misch metal absorb gases effectively.	Gettering in range 400 to 900 F.
Zirconium	Forms stable solid solutions with gases such as O_2, N_2, CO, CO_2. Parts mounted so portion at 750 F takes up hydrogen while hotter portions absorb other gases.	Used in vacuum tubes as cathode or grid supports. Anodes of transmitting tubes may be coated with zirconium powder.

naces frequently consist of a ceramic tube externally wound with resistance wire. They are sealed at one end and connected to the vacuum pumps at the other. When the size of the operation is too great for tubes, the muffle furnace is preferable, with resistance wire or ribbon either externally or internally wound on the muffle. Muffle materials generally used include alundum, zircon, and bonded silicon carbide. Among resistor materials used are tungsten, molybdenum, Nichrome, Chromel and Kanthal. Heating elements may be covered with alundum cement to hold them in place and to protect them from contamination by other furnace materials or vapors. For heat insulation between heater core and the outer furnace shell, low thermal conductivity grain, usually alumina, magnesia or Sil-O-Cel, is used. Lightweight insulating firebrick and zircon brick are also satisfactory for thermal insulation and may be outgassed. The outer furnace shell is generally stainless steel, iron or brass.

Vacuum arc furnaces are used for melting materials like titanium and zirconium, which react readily with most crucible materials, or molybdenum, which has an extremely high melting point. An arc is struck between the ingot to be melted and a permanent electrode of tungsten, molybdenum or graphite. An alternate method employs a consumable electrode, usually a powder metal or sponge compact, and has several advantages, including accurate control of melt-off rate and of alloying techniques. The molten metal is frequently collected in a water-cooled copper mold, where it solidifies and contracts so that it does not adhere to the mold. One-ton ingots of molybdenum are produced commercially by arc-casting in vacuum or in low-pressure gas atmospheres. Zirconium, tantalum and titanium are also vacuum arc-melted in practice.

For comparatively low-temperature operations such as vacuum thermal reduction of metallic compounds, gas-fired retorts have been used. These were thick, evacuated alloy steel tubes heated externally.

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Materials for Use above 2200 F

Material	General Characteristics	Applications
Alumina	Pure, fused aluminum oxide can be used to about 3400 F. The refractoriness is reduced by addition of clay binders.	Furnace linings, crucibles, tubes, muffles. Can be used with nichrome, platinum, molybdenum and tungsten elements. Crucibles used in vacuum melting of ferrous and non-ferrous alloys, copper, manganese, boron, germanium and other metals.
Beryllia	Excellent hot strength, thermal shock resistance, high thermal conductivity: appears to be more inert toward carbon than other oxides. Reacts with aluminum, magnesium, and silicon to form less refractory oxides. Upper operating limit in vacuum is about 3700 F. Beryllia powder is toxic.	Can be used as supports, liners and shields in contact with graphite. Used as crucibles for melting nickel, platinum, beryllium. Reacts with molybdenum and tungsten starting at temperatures of 3400 to 3600 F.
Graphite and Carbon	Low vapor pressure, high radiation coefficient, high heat conductivity. Limitation is affinity of oxygen and tendency to reduce oxides of the commercial refractories above about 2375 F. Can be degassed at 3100 F. in high vacuum.	Used as resistors; clay-bonded graphite crucibles to temperatures of 2200 F. Electrode graphite crucibles above that temperature. Zirconium, titanium, silver, thorium, others melted in graphite. Graphite molds in vacuum furnaces, heavy-walled anodes in electron tubes, x-ray targets.
Magnesia	Pure magnesia has high thermal expansion and is sensitive to thermal shock. Although sintered magnesia has been used under high load conditions, ordinary magnesite refractories generally used under light loads. High thermal conductivity offset by zirconia backing at temperatures to 3450 F.	Sintered magnesia linings have been used in commercial vacuum furnaces at 3450 F. Magnesia crucibles suitable for vacuum melting ferrous and nonferrous alloys, nickel, chromium, copper, platinum, gold, manganese, and other metals.
Molybdenum	Widely used at high temperatures in vacuum because of high melting point and strength. Oxides volatile at comparatively low temperatures but reform in vacua up to 1800 F. Starts reacting with alumina at about 3300 F; with beryllia, zirconia and thoria at higher temperatures.	Used as supporting heating elements, structures, radiation shields, protective sleeves in vacuum furnaces; anodes and grids in vacuum tubes.
Mullite	Consists essentially of $3A1_2O_3.2S:O_2$. Higher softening point than quartz and less permeable to gases at high temperatures. Thermal decomposition at about 3100 F.	Used for tubes in high vacuum furnaces up to about 2300 F.
Nitrides	Not available commercially, offer good possibilities for melting metals without contamination; are electrical conductors, can be induction heated.	Boron nitrate can be used as barrier between graphite crucible and oxide refractory.
Silicon Carbide	High thermal conductivity, resistant to thermal shock.	Bonded silicon carbide used for crucibles and muffles. Heating elements to about 2550 F.
Sillimanite	Typically 2 parts alumina to 1 part silica, decompose at about 2900 F. Service temperature in vacuum limited to about 2500 F. Clay-bonded sillimanites have lower safe operating temperatures.	Furnace tubes in high vacuum furnaces, insulating brick.
Sulfides	Although sulfides generally oxidize in air, they are applicable in vacuum. Several have low vapor pressures and high melting points.	Refractories for high vacuum service. Cerium sulfide crucibles for melting metals.
Tantalum	High melting point, low vapor pressure, and good hot strength. Strong affinity for oxygen, nitrogen, carbon monoxide, carbon dioxide, which cause embrittlement. Absorbs hydrogen below 1100 F.	Used as getter and for transmitting tube parts. Tantalum powder can be sintered on molybdenum or tungsten anodes.
Thoria	Highest melting point of any pure oxide; low vapor pressure; highly sensitive to thermal shock. Reacts with beryllia around 3700 F., and with magnesia at 4000 F.; no reaction with tungsten, molybdenum or zirconia up to 4200 F.	Crucibles suitable for melting iron, zirconium, thorium, osmium, etc.
Tungsten	Most refractory of the metals but subject to embrittlement through grain growth at elevated temperatures. Heaters are carefully heat treated to develop stable crystal structure.	Used as heating elements. An alloy of 50% tungsten-50% molybdenum is used in indirectly heated cathodes of electron tubes.
Zircon	Zirconium silicate has a lower thermal expansion coefficient and higher resistivity than most other refractories. It has good heat shock resistance.	Crucibles used for melting various non-ferrous metals and stainless steel, aluminum, nickel alloys, titanium alloys, copper and other metals. Tubing has been used successfully in high vacuum furnaces to 2100 F. Muffles, bricks and cements also used.
Zirconia	Excellent thermal insulator. Pure zirconia changes in crystal structure at about 2000 F with considerable volume change. Zirconia ware is generally stabilized by addition of other oxides. Zirconia reacts with basic oxides to form other compounds.	Crucibles used for vacuum melting of non-ferrous metals; usable in contact with molybdenum or tungsten at temperatures to 3600 F.

Selecting Ceramic Coatings

Five general types of coatings now available. . . . Work continues to

A Ceramic Coating . . .

Must Meet These Requirements:

1. It must adhere well to the base metal.

2. It must be thin. Thin coatings improve adherence and minimize cracking, chipping and thermal shock damage. They also reduce weight, improve ability to withstand centrifugal forces, and improve resistance to tearing of the the "bisque" (the dry but unburned coating) on firing.

3. It must have physical stability. Resistance to mechanical impact and high frequency vibration are particularly important.

4. It must have chemical stability. Primarily it must be inert to normally corrosive gases and have a low rate of solvent action on the base metal.

5. It must have high thermal shock resistance.

6. It must be impervious to gases.

7. It must have a thermal expansion coefficient fairly close to that of the base metal. When the coating thickness exceeds 2 to 3 mils matching of base metal and coating thermal expansion coefficients becomes critical and the coefficients should match almost perfectly.

8. It must be free of "reboil"—gas bubbles usually occurring at or near 1000 F when coated mild steel is reheated after the original firing operation.

To Perform These Functions:

1. Protect the base metal from corrosion by or absorption of gases. Ceramic coatings give protection against reducing or oxidizing atmospheres, sulfur dioxide or trioxide, carbon, sulfur and, to some extent, chlorine.

2. Protect the base metal from erosion by high-velocity gases.

3. Reduce warping, buckling or cracking failures in sheet metal by decreasing hot spots.

4. Serve as a heat barrier. This can be done with refractory insulating materials or, in thin vitreous coatings, by including low-emissivity ingredients which can be effective when the hot gases are quite luminous.

5. Increase strength and stiffness by lowering effective operating temperature.

6. Allow use of thinner gage metal without forfeiting life.

7. Increase flexural rigidity by increasing thickness of part. Some other process, such as metallizing, might be more satisfactory where this is the primary consideration.

8. Allow special characteristics to be incorporated in surface, such as special textures, smoothness, various electrical properties, mechanical prestressing, abrasion resistance and anti-galling characteristics.

9. Increase fatigue strength by elimination of surface stress raisers. Also reduce corrosion fatigue, dampen vibrations.

● CERAMIC COATINGS, essentially refractory versions of the conventional glassy porcelain enamels, are generally considered for one of three purposes:

1. To allow substitution of less strategic alloys without sacrificing service life.
2. To lengthen the service life of existing parts.
3. To allow use of existing parts at higher operating temperatures.

Each of these objectives has a particular significance at the present stage of jet engine development. As a result there is increasing interest in the use of ceramic coatings for jet engine parts.

Ceramic coatings were applied to automobile mufflers before World War II. During the war, ceramic coatings were used on turbo-superchargers. Now they have only limited application on jet engine parts, but many manufacturers of jets, guided missiles and conventional aircraft, here and abroad, have ceramic-coated jet parts under development and test. Present development work on ceramic coatings has three main objectives:

1. Development of more refractory compositions and of insulating coatings.
2. Modification of compositions to fit the growing list of metals and environments contemplated by design engineers.
3. Determination of physical and engineering data on coated specimens and parts for the use of design engineers.

In general, a ceramic-coated part is more effective if it is considered as a special compounded material of definite and distinct properties rather than merely as "painted" metal.

Types of Coatings

Ceramic coatings of possible use in aviation gas turbine applications can be classified as follows:

1. Ordinary refractory coatings similar to those used on automobile mufflers. These are essentially porcelain enamel formulations with refractory additions and are applied in conventional enamel thicknesses (3 to 8 mils).

for Jet Engine Parts

by W. C. ROUS JR., Aircraft Gas Turbine Div., General Electric Co.

develop new and modify old compositions to meet new demands.

2. Extremely thin (½-2½ mils) coatings of the above composition. An example is Bureau of Standards Type A-418.

3. Highly refractory metal-bonded oxide, carbide or nitride coatings, generally known as "cermets." An example is Ohio State's magnesium oxide-65% nickel flame-sprayed coating.

4. Refractory insulating coatings attached to the base metal by cementing or by mechanical techniques.

5. "Ceramic paints" which can be brushed on and require no firing prior to use.

Coatings for Mild Steels—Coatings for mild steels are generally variations of the Bureau of Standards A-19 coating which has a high aluminum oxide content (composition given in accompanying table). A-19 has a higher thermal expansion coefficient than conventional coatings and therefore more closely matches the expansion of the base metal in heating. However, it also has a higher softening temperature which means it may be under greater stress after cooling to room temperature due to the higher temperature at which it became rigid. A-19, a dark grey matte coating, is satisfactory for temperatures approaching 1200 F and has good thermal shock resistance. Improved resistance at temperatures up to 1250 F can be obtained from A-19H which has a still higher aluminum oxide content. The A-19 coating matures at 1580 F and A-19H matures at 1620 F.

Commonly used mild steels are 1010 and Ti-namel. For better hot strength, low alloy steels such as 4130, N-A-X, 17-22-V and Chromalloy are used as the base metal. If more than a single coating is to be applied to mild steel, it is important that the carbon content not exceed 0.15%.

Coatings for Stainless Steels— Another Bureau of Standards coating, A-418, is widely used on stainless steel. (See table for composition.) Its texture ranges from semi-matte to semi-gloss, depending on how it is applied. The Solaramic 5210-2C coating is glossier. Both will protect stainless Type 321 from corrosion at 1700 F for at least 200 hr (in laboratory testing) and will withstand 10 cycles of heating to 1600 F and quenching in water. Maximum usable temperature for these coatings is 1800-1900 F.

Ceramic-coated stainless has been used to replace uncoated high alloys where straight corrosion protection of hot parts is needed. In some cases, significant savings in critical alloying elements can be made. However, experience on the J-47 engine liners has been mixed, with both uncoated Inconel and coated 321 stainless proving superior in different models and under different conditions. Other base metals successfully coated include Types 310, 347 and 430, and 19-9DL.

Coatings for Nonferrous Metals—In certain limited applications where the temperature exceeds 2000 F, L-605 (cobalt - chromium - tungsten - nickel) burns out. Several vitreous coatings have increased the engine operating time of this metal. Ceramic coated Hastelloy B withstands laboratory testing at 1800 F. On the other hand, A-418 has been applied to welded Inconel W stress-rupture specimens without appreciable advantage. Other base metals being evaluated include S-816, Vitallium, A-286, N-155, Inconel and Hastelloy X.

Insulating Coatings—A good example of a mechanically attached insulating coating is the system originated by the General Electric Research Laboratory. Stainless sheet is punched to form projecting tabs (U. S. Patent No. 2,564,497) and is then covered with a thin vitreous coating designated 8473-C1. This is followed by a thick mixture of magnesium oxide and 8473-C1 which matures at 1830 F. Development of this type of coating is taking place slowly, but progress is being made.

Since the melting point of magnesium oxide is 5072 F, the operating temperature for this type of coating is limited by 1) the refractoriness of the glassy base coat and binder, 2) the time-temperature dissolving of iron from the base metal at temperatures above 2500 F (the melting point of iron oxide), 3) the thermal expansion characteristics at the interface between coatings, and 4) the thermal expansion characteristics at the interface between the vitreous base coating and the base metal.

Ceramic Paints — The so-called ceramic paints are normally oxides or carbides in a soluble silicate vehicle and are intended for field applications where starting up the engine will mature the binder. These coatings can be used for oxidation and corrosion protection or for radiation control. One such coating, developed by the University of Illinois and designated as CP44, was used on airplane exhausts during World War II; it cut down the visible radiation from red hot exhaust stacks as much as 90%. This type of coating is of a temporary nature, feasible for repair work or for special uses where conditions are not extremely severe. A more permanent coating would be obtained by application of a fired base coat before engine assembly, followed by application of a ceramic

Two Important Ceramic Coatings

	A-19	A-418
Composition, % by wt:		
SiO	36.3	28.6
BaO	—	33.7
B_2O_3	14.1	4.9
Cr_2O_3	—	23.0
CoO	1.3	—
ZnO	—	3.8
NiO	0.5	—
K_2O	3.6	—
Al_2O_3	26.4	0.8
CaO	4.5	2.7
Na_2O	12.3	—
MnO	1.0	1.9
Clay Mill Addition, % by wt.	10.0	5.0
Firing Temp, F (approx.)	1600	1875
Firing Time, Min. (approx.)	10	10

paint after engine assembly. The glassy base coat provides more permanent adherence for the insulating coating.

Coating Tests and Failures

Prior to engine testing, ceramic coatings are usually subjected to laboratory screening tests. They include: thermal shock test from nominal operating temperature to water for 10 cycles, extended heating at about 200 F above operating temperature for 48 to 72 hr, adherence tests involving bending or deforming in a die or press, impact tests, stress-rupture and fatigue tests, and long cyclic gas heating tests.

Tests run on coating materials before application include Button fusion tests and coefficient of expansion correlations by interferometer techniques or by measurement of expansion and contraction forces in a coated sheet metal ring. Microscopic examination is used to determine base metal and coating deterioration during various phases of laboratory testing. Currently, the Wright Air Development Center is acting as an initiating and liason agent in an effort to standardize laboratory screening tests throughout the country for ceramic coatings with Air Force applications.

Although coatings may not be needed on both sides of a part for protective reasons, a great deal of needless failure due to distortion can be eliminated by coating both sides. Such distortion is caused by the unbalanced stress set up by the difference in expansion and contraction rates between the coating and the base metal. Some designs may resist distortion, but the unbalanced stress will still exist.

Coating failure caused by excessively large compression stresses (as where temperature gradients and thermal shock are augmented by mechanical buckling stresses) show up as bare areas where the coating has popped off. Sometimes fine cracks allow gases to escape freely from the metal; in other cases the constriction of these fissures and the fact that the temperature exceeds the softening point of the glass result in formation of blisters. Where failure in tension occurs, rows of blisters may occur along the line of rupture. In compression failure the distribution of cracks and blisters tends to be more random.

Coating failure may also occur as a result of oxidation in the base metal under the coating. Usually the oxide is absorbed into the coating as it is formed until a saturation level is reached. Then adherence usually deteriorates and the coating flakes off.

Coating Processes

Ceramic coating processes can logically be considered in three parts: formulation of the coating, preparation of the metal surface, and application and firing of the coating.

Coating Formulation — Ceramic coating formulations are inorganic, earthy materials composed mainly of quartz, feldspar, clay, chromic oxide, aluminum oxide, borox, cryolite, fluorspar and calcium-barium-magnesium carbonates. Compounds other than oxides are considered in terms of their theoretical oxide components for the purpose of calculating the batch composition. The sequence of coating formulation is as follows:

1. Weigh, mix, smelt, quench, dry and store as frit.
2. Weigh frit with mill additions; ball mill, test, store and age.
3. Adjust specific gravity pick-up and set-up characteristics of coating slip.

Metal Preparation—Preparation of sheet metal for ceramic coating is subject to several variations depending on the type of base metal, the characteristics of the coating and its purpose. Following are three sequences used on mild steel:

1. Clean chemically, water rinse, pickle, water rinse, neutralize, dry.
2. Scale, pickle, water rinse, plate nickel flash, water rinse, neutralize, dry.
3. Anneal, blast.

A more detailed outline of one satisfactory sequence for stainless steel is given in the accompanying table.

Application and Firing—The controlled coating slip is applied to the prepared metal surface by dipping or spraying. The coating is then dried to form a bisque.

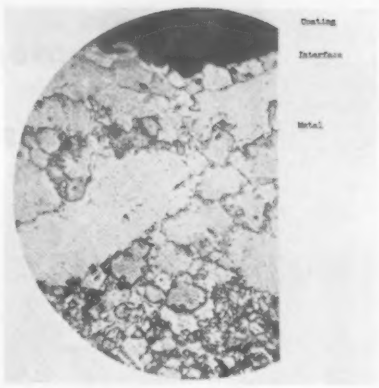
Ordinarily, maturing temperatures range from 1000 F for coatings on aluminum to 2000 F for coatings on Inconel. High temperature coatings on mild steels are usually fired at about 1600 F. Firing is done at the minimum temperature that will permit maturing within a practical time limit. At unnecessarily high firing temperatures metal deformation and excessive oxidation occur. Sometimes neutral or reducing atmospheres are helpful in firing. On low carbon steels the coating must fuse and seal off oxygen early in the heating cycle before excessive oxidation can occur. On alloy steels, however, fusion of the base coat must be delayed until enough metal oxide is produced to promote good adherence. Firing temperatures for alloy steels commonly range from 1750 to 1950 F.

Higher firing temperatures have been used with some materials. A glass-like modified barium aluminum silicate coating has been fired on alloy steel at 2200 F. Firing temperatures ranging from 2200 to 2800 F have been used with a chromium-frit glass coating in attempts to protect molybdenum.

One Method of Preparing Stainless Steel for Ceramic Coating

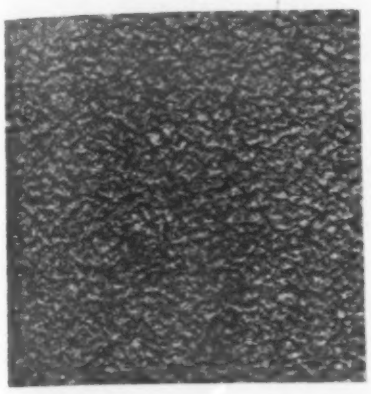
1. Clean
   a. Emulsion clean ½–1 min.
   b. Hot water rinse (180–212 F).
   c. Immerse in heavy duty alkaline cleaner 5–15 min.
   d. Cold water rinse.
   e. Hot water rinse (180–212 F).
2. Anneal—10 min at 1800 F. Cool.
3. Pickle
   a. Dip in 15% hydrochloric acid at 160–180 F for 10–15 min.
   b. Hot water rinse (180–212 F).
   c. Dip in 10 nitric-2% hydrofluoric acid at 180–200 F for 15–30 min.
   d. Hot water rinse (180–212 F).
   e. Cold water rinse (air water gun).
   f. Neutralize in sodium carbonate (4 lb per 100 gal water) at 160–180 F for 5–10 min.
   g. Hot water rinse (180–212 F).
4. Mask—all areas not to be coated and not to be blasted.
5. Blast.

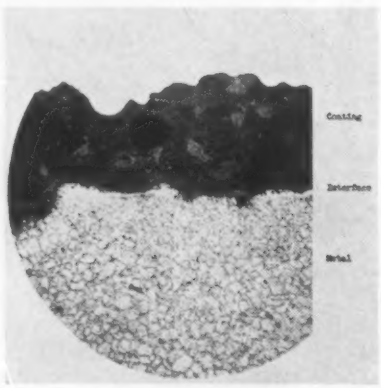
Four Typical Ceramic Coatings



A-19H, FIRED UNDER OXIDIZING CONDITIONS

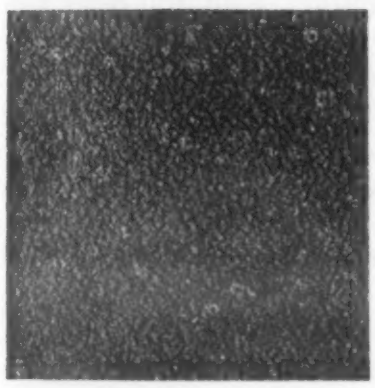
Note grain growth at the metal surface.

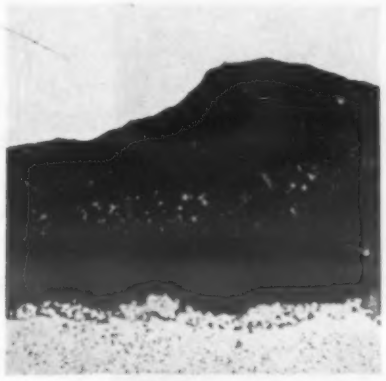


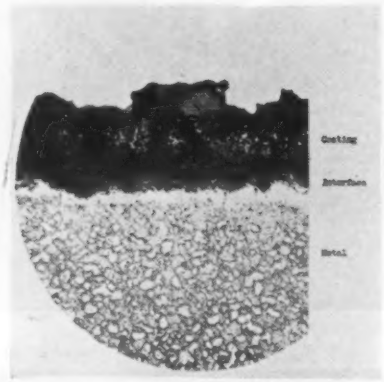


XT-955, FIRED UNDER OXIDIZING CONDITIONS

Note 1-2 mil decarburized layer under interface. The layer, ranging up to 8 mils in thickness, is present before coating and the coating process does not seem to affect it. Of the coatings shown here, this one consistently demonstrated the best adherence, based on a 90-deg bend test.

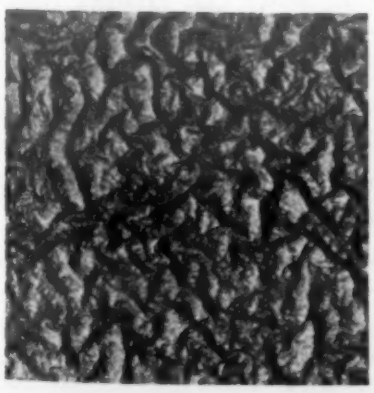


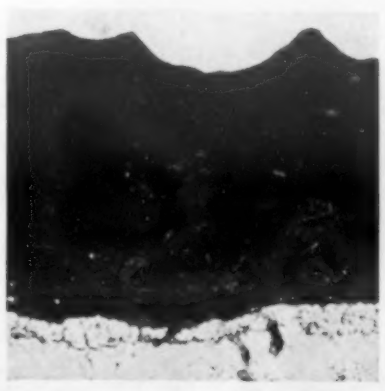


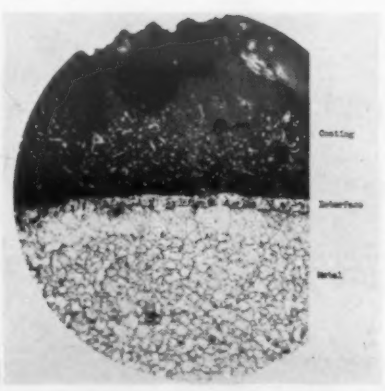


XP-49L, FIRED UNDER OXIDIZING CONDITIONS

Here the decarburized layer under the interface measures 4-6 mils.







A-19H, FIRED UNDER REDUCING CONDITIONS

The interface structure here is markedly different from that in the other coatings. This coating was fired in a neutral to reducing atmosphere.

Four different ceramic coatings, magnified, after 48 hr at 1400 F. Coating XT-955 may have 1300 F applications. Coatings A-19H and XP-49L may have 1100 F applications.

Magnified cross-section of the same specimens. The steel is 17-22-V with about 1% chromium, small additions of molybdenum and vanadium, and about 0.2% carbon.

Another magnified cross-section of the same specimens showing the base metal in greater detail.

Materials at Work

Here is materials engineering in action . . .

New materials in their intended uses . . .

Older, basic materials in new applications . . .

VITREOUS ENAMEL ENHANCES SHEET ALUMINUM Sheet aluminum bowls, vases, ash trays, candle sticks, plaques and murals are now being coated and decorated with vitreous enamel by Edward Winter of Cleveland. Commissioned by the Aluminum Co. of America and working in the laboratory of the Ferro Corp., he fuses the low temperature enamels to the aluminum base at a 1000 F temperature in a period of 5 to 6 min. A variety of colors and tones are possible by mixing and blending the metallic oxides used for coloring.

The sheet aluminum is first formed by hammering or spinning, then receives a special cleaning and pickeling in sulfuric acids and other solutions to cut the dirt and grease on the metal. The enamel is then milled and applied to the metal while it is wet. A special design pattern is then worked in the wet enamel, and the piece is dried at a 350 F temperature for about 30 min before firing at 1000 F. This is followed by polishing and stoning operations.

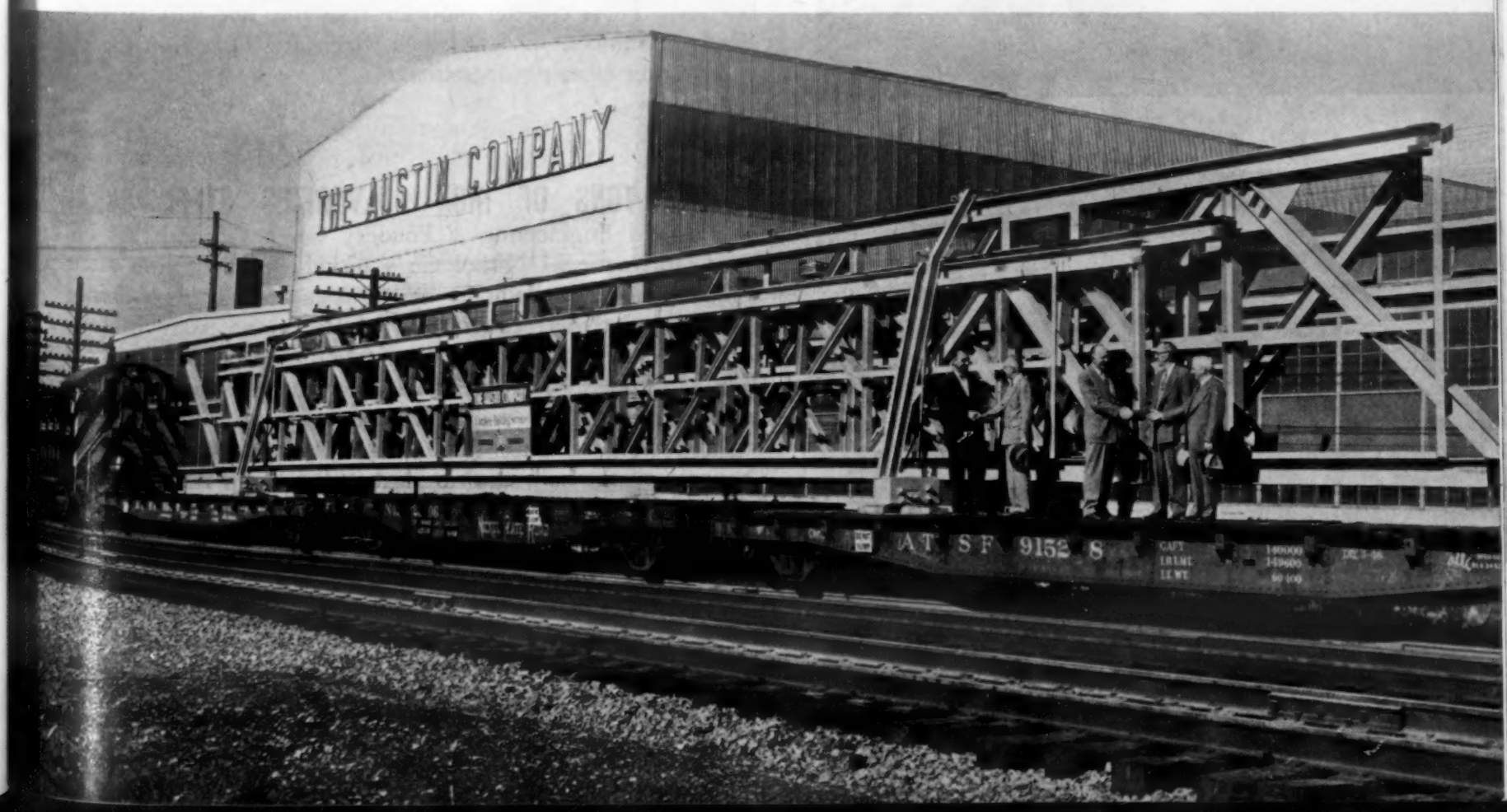
Enameled aluminum is unbreakable. The metal can be twisted and bent without chipping or cracking the coating since the enamel forms a stable, permanent bond with the metal.

As well as the obvious decorative applications, the industrial field can use enamel coated aluminum for stoves, refrigerators, table tops, furniture, washing machines, store fronts, and for many other applications.

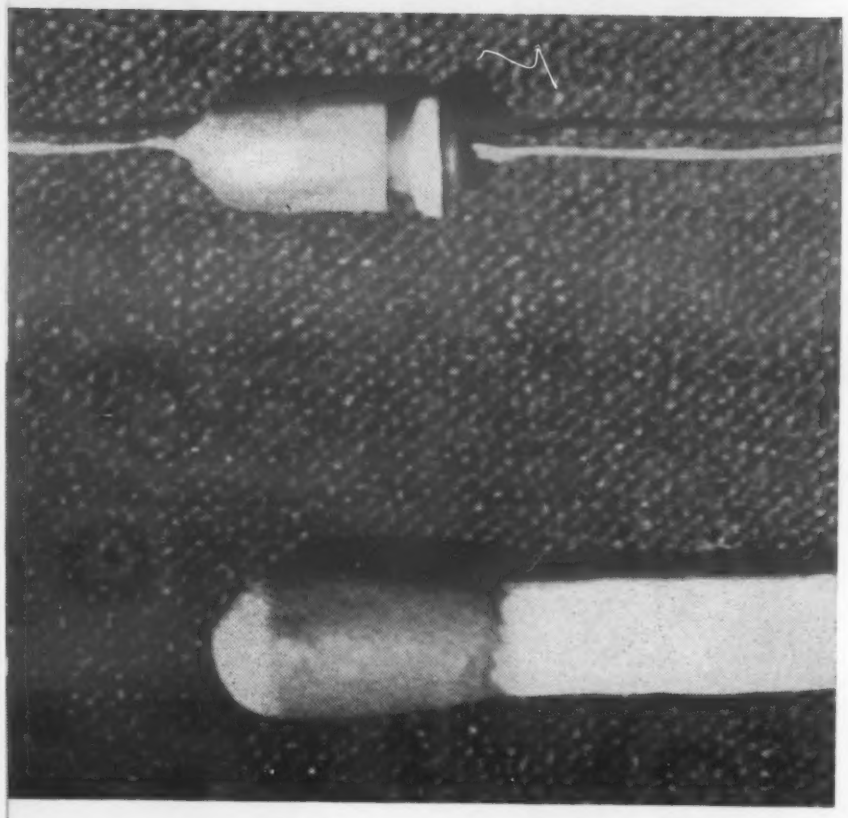
CORE FOR TURBINE HOOD This 120,000 lb rough finished core, a mixture of sand, clay and pitch, is being lifted from the pit in which it was molded at G-E's Turbine Div. at Schenectady. When finished it will form the inside contour of a casting which will be the upper hood of a turbine rated at 100,000 kv-amp. The completed hood will have enough space to contain a two-room apartment.

LONG STRUCTURAL STEEL TRUSS Designed and fabricated by The Austin Co., a 135 ft truss, the longest to be shipped by rail from Cleveland, has just been transported to Jersey City, N.J. to become a part of the new conveyor system at the Colgate-Palmolive manufacturing plant. Loaded with five other similar H-section trusses of shorter length, the load required three flatcars.

The truss is distinguished by its novel construction and the complete absence of joint plates. Its design is of the all-welded H-section type, which reduced the weight and increased the rigidity, all-important factors in shipping and erecting the complete assembly.



Materials at Work

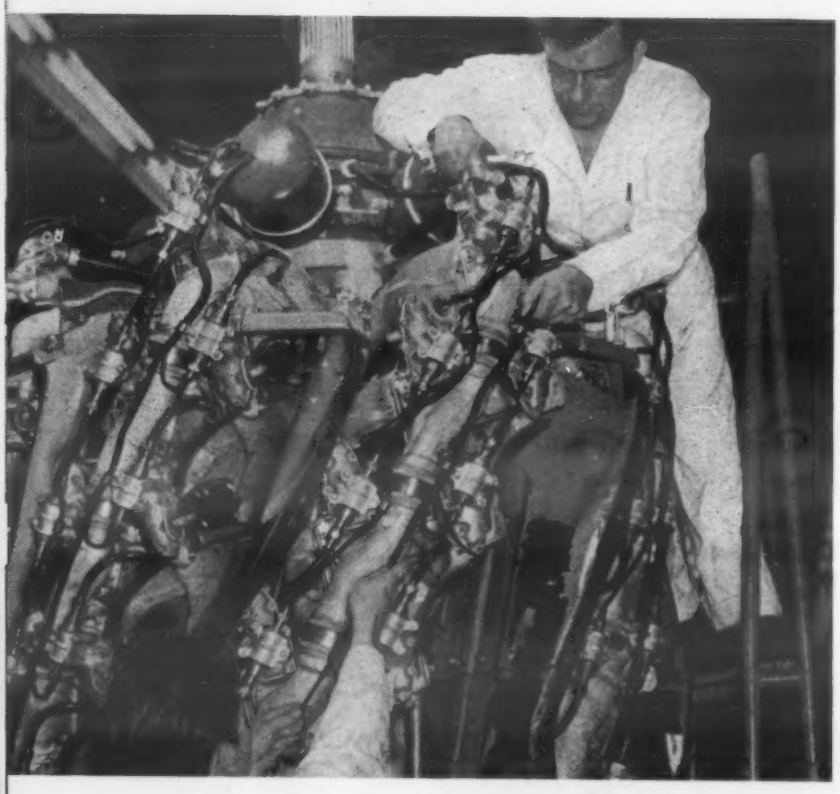


TINY TANTALUM CAPACITOR DESIGNED AS PARTNER FOR TRANSISTOR

This "micro-miniature" capacitor shown beside a match head is 1/8 in. dia, and 5/16 in. long. Designed by General Electric Co.'s Capacitor Dept., it is the first in a new line of small capacitors being manufactured by G-E for miniaturized equipment. It is believed to be the smallest high capacity unit designed for low voltage, direct current applications.

It has a tantalum anode oxidized to the voltage rating, enclosed in a silver case, and impregnated with non-acid solution. A synthetic plug in the end of the case is roll-crimped into place and a solderable tin-coated nickel lead is lap-welded externally to the projecting tantalum anode lead, permitting connection up to the case. The case itself is the cathode, and is equipped with a tin-coated copper lead soldered to the case.

The unit is designed to operate over a temperature range of –4 to 120 F and is suitable for storage at –75 F. It is available in ratings from 2 to 16 v, 4 to 0.7 microfarads. A larger 1/2-in. capacitor with similar characteristics and the same voltage range, but with 8 to 1.5 microfarads, is also being manufactured.

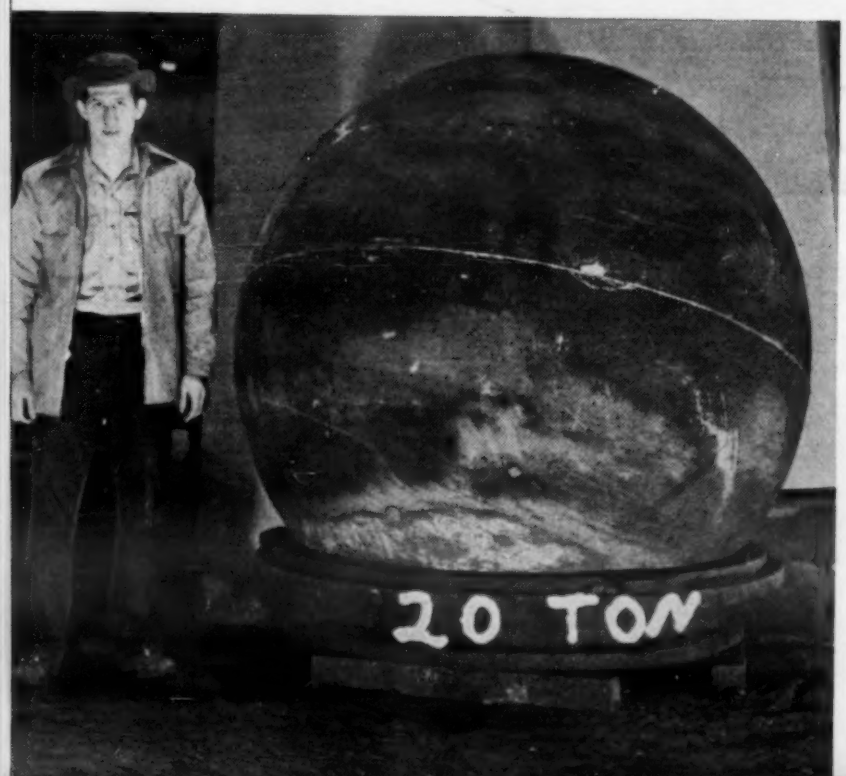


VINYL PLASTIC PROTECTS AIRCRAFT IGNITION HARNESS

A new type Geon vinyl plastic coated low tension ignition harness is shown here being installed on a Wasp Major 28 cylinder engine used on Boeing Stratocruisers. Seven such harnesses are used on these engines to carry low voltage from the magnetos to the transformer coils.

The harnesses, manufactured by Scintilla Magneto Div., Bendix Aviation Corp., consist of an insulated conductor wrapped in nickel braid and covered with a nylon fabric which has been coated with Geon vinyl latex. Formerly, maintenance trouble had occurred when various physical strains and chemical reactions caused the covering to chafe through the insulation to the conductor. The Geon vinyl latex, a product of B. F. Goodrich Chemical Co., now provides an abrasion resistant coating which is said to withstand chafing, giving a longer-wearing harness.

In addition to increased abrasion resistance, the vinyl latex is said to provide better moisture resistance and withstand the effects of mineral spirit solvents which are flushed on the engine during cleaning operations.



TWENTY TONS OF IRON PULVERIZES STEEL SCRAP

The United Engineering & Foundry Co. has found that Ni-Hard, International Nickel Co.'s nickel-chromium iron alloy, contains the high hardness and abrasion-resistance combined with the relative freedom from brittleness necessary in drop balls to do the primary fragmentation job in a steel scrap recovery process. The metal does not tend to split due to internal shrinkage and cracks, as does cast steel, and it seems to have less resilience than steel. This factor reduces the "bounce" of the ball, allowing a more thorough fragmentation job.

Six of these balls are now on order by Heckett Engineering, Inc., one of the pioneers in developing methods of recovery of slag dump scrap. Frequent breakage of the standard drop balls previously used raised production costs to such a point that the Ni-Hard balls have now been purchased in the belief that they will prove definitely economical on the basis of long-time service.

Engineering Coppers

by **JOHN L. EVERHART,** Associate Editor, Materials & Methods

MATERIALS & METHODS
Manual No. 100

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and applications.

DECEMBER 1953

The factors underlying the majority of applications of copper are high electrical and thermal conductivity, corrosion resistance and ease of working and joining. A number of modified coppers have been developed commercially to take advantage of one or more of these properties. To assist in selecting the proper grade for a specific application, this Manual presents information on the following points:

- *Commercial Grades*
- *Engineering Properties*
- *Applications*
- *Forming and Fabricating*
- *Joining Practice*
- *Cleaning and Finishing*

Introduction

In industrial practice the term "copper" is not limited to the commercially-pure metal but can include as much as 2% of other elements. Thus, the Copper and Brass Research Association defines copper as "the element copper commercially pure or alloyed with not more than 1% of other elements . . . ". In ASTM standard B224, which covers refinery shapes and wrought products, the definition is ". . . copper containing less than 0.5% of alloying elements has been included in the term copper." In ASTM standard B119, covering cast copper base alloys, the term "copper" includes "not over 2% total of arsenic, zinc, cadmium, silicon, chromium, silver or other elements". For the purposes of this manual, "copper" will include those materials which contain at least 99% copper.

Since the coppers have the highest electrical conductivities of all commercial metals with the exception of silver, they are widely employed in electrical applications. It should be mentioned that the choice of 99% as the line of demarkation between copper and copper alloys arbitrarily excludes certain other materials such as beryllium copper and Grade E phosphor bronze which also find considerable application in the electrical field. These materials have been covered in other Manuals. The corrosion resistance of copper also leads to numerous applications. Large tonnages are used for water tubing and architectural purposes. Copper can be formed readily and is probably the easiest metal to soft solder.

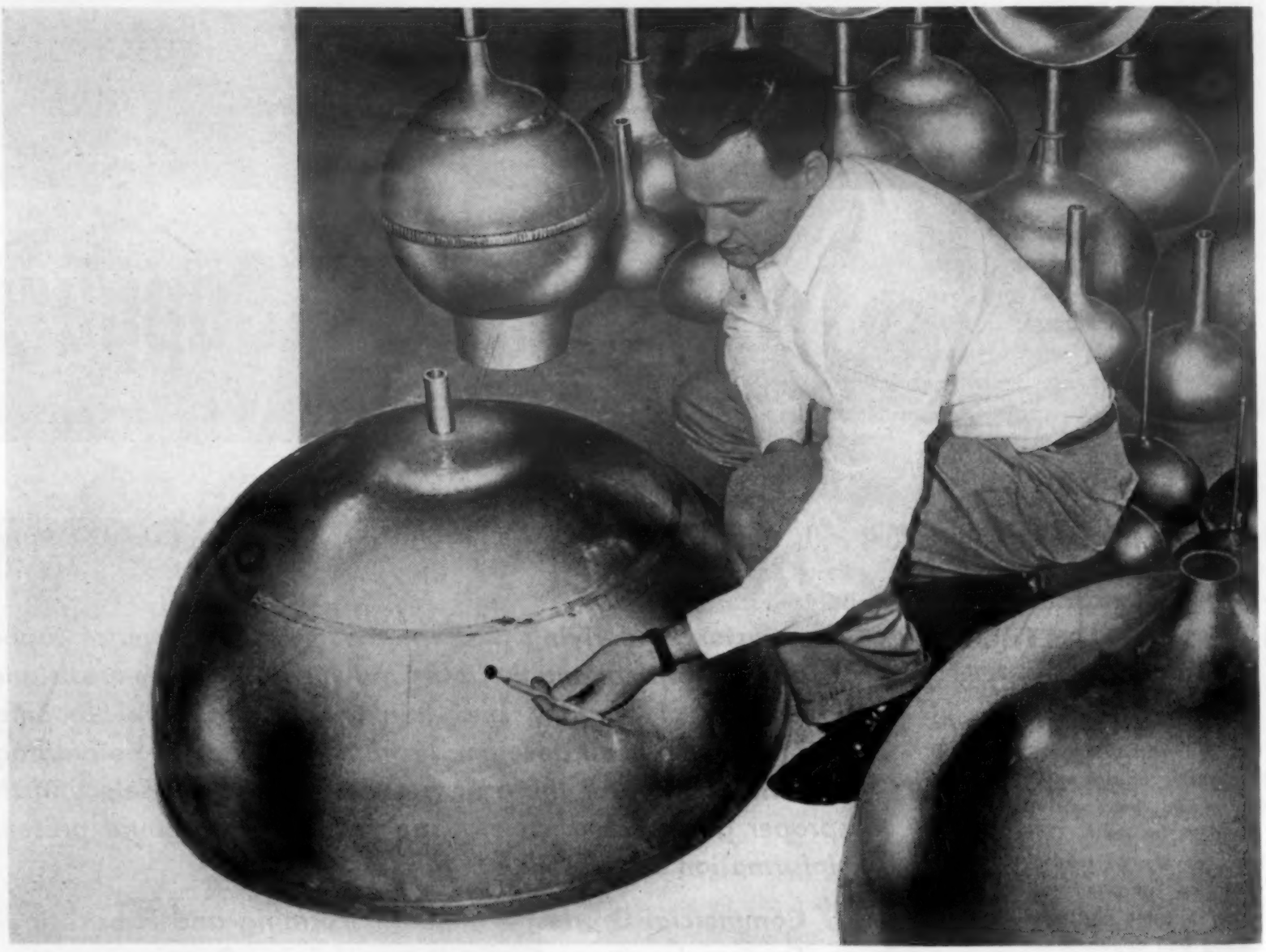
Although there are many possible combinations which fall within the term "copper" as defined, there are about 20 distinct types which are commercially available. The characteristics of these coppers are discussed in this Manual to assist the engineer in selecting the best material for his requirements.

Classification of the Coppers

The coppers can be subdivided into two major groups, 1) those containing controlled quantities of oxygen as cuprous oxide and 2) those which contain no cuprous oxide. The former are called tough pitch coppers, a term derived from the melting practice. The coppers containing no cuprous oxide can also be divided into two groups, 1) those which are produced by deoxidizing the melt with a metal or metalloid and 2) those which are produced without oxygen by controlled melting or other means. The more important coppers are designated as follows.

Electrolytic Tough Pitch Copper is most widely used of the coppers. It contains from 0.02 to 0.05% oxygen as cuprous oxide, which does not materially affect the conductivity or strength of the material. However, it does reduce ductility somewhat, although this effect is apparent only if

Spun copper hemispheres are soldered into double walled spheres for use in the fabrication of bottles to hold liquified gases.



Classification of Coppers

Type of Copper	Designation	Nominal Composition of Commercial Materials, %			
		Cu + Ag	O	P	Others
Tough Pitch Coppers[1]					
Electrolytic tough pitch	ETP	99.9+	0.04		
Fire-refined high conductivity tough pitch	FRHC	99.9+	0.04		
Fire-refined tough pitch	FRTP	99.88[3]	0.04		
Arsenical tough pitch	ATP	99.4	0.04		Arsenic 0.15 to 0.50
Silver-bearing tough pitch	STP	99.9	0.04		Silver by agreement[4]
Silver-bearing arsenical tough pitch	SATP	99.4	0.04		Silver by agreement[4]
Selenium-bearing tough pitch	SETP	99.4	0.04		Selenium 0.6
Tellurium-bearing tough pitch	TETP	99.5	0.04		Tellurium 0.5
Oxygen-Free Coppers[1]					
Oxygen-free without residual deoxidants	OF	99.9[3]			
Oxygen-free, silver bearing	OFS	99.9			Silver by agreement[4]
Oxygen-free, tellurium-bearing	OFTE	99.4			Tellurium 0.6
Deoxidized Coppers[1]					
Phosphorized, high residual phosphorus	DHP	99.9+		0.015/0.040	
Phosphorized, low residual phosphorus	DLP	99.9		0.004/0.012	
Phosphorized, silver-bearing	DPS	99.9		0.040 max	Silver by agreement[4]
Phosphorized, arsenical	DPA	99.68		0.040 max	Arsenic 0.15 to 0.50
Phosphorized, tellurium-bearing	DPTE	99.4		0.007 max	Tellurium 0.6
Other Coppers[2]					
Leaded		99.0			Lead 1.0
Boron deoxidized		99.98			Boron 0.02
Cadmium		99.0			Cadmium 1.00
Chromium		99.05			Chromium 0.85, 0.10 Silicon or other element

Notes:
[1] *ASTM Standard B224-52.*
[2] *Not classified in B224-52.*
[3] *Arsenic 0.012 max; Antimony 0.003 max; selenium + tellurium 0.025 max; nickel 0.05 max; bismuth 0.003 max; lead 0.004 max.*
[4] *Common grades 10 to 15 oz/ton silver and 25 to 30 oz/ton silver.*

the copper is severely cold worked. In joining by brazing or welding, cuprous oxide also introduces problems because of the possibility of embrittlement of the copper if it is heated in a reducing atmosphere.

Oxygen-free Copper contains no residual deoxidant. It is a high conductivity copper which is somewhat more ductile than tough pitch, and can be more severely cold worked.

Phosphorized Copper is the most common of the deoxidized coppers. The residual phosphorus remaining after deoxidation has a detrimental affect on electrical conductivity. In a grade produced for non-electrical purposes conductivity is reduced to 85%. Another grade is available which contains a lower content of residual phosphorus and conductivity is not so seriously affected.

These three are the basic coppers. All three are modified by addition of other elements to achieve special properties for certain applications. Among the elements added are arsenic, silver and lead.

Arsenical copper is obtained in the United States from certain mines in the Lake region of Michigan. In Europe, where the use is more extensive, it is produced by adding arsenic to tough pitch copper. The addition

Commercial Copper Shapes*

Commercial shape designations used in the copper industry differ somewhat from those used for steel. The following terms define the major items.

Wire Bar—Refinery shape for rolling into rod (and subsequent drawing into wire), strip or shape. Square in cross section.

Cake—Refinery shape for rolling into plate, sheet, strip, or shape. Rectangular in cross section.

Billet—Refinery shape primarily for tube manufacture. Circular in cross section.

Wire—A solid section, other than strip, furnished in coils or on spools, reels, or bucks.

Tube—A hollow product of round or any other cross section, having a continuous periphery.

Pipe—Seamless tube conforming to the particular dimensions commercially known as "Standard Pipe Sizes."

Shape—A solid section, other than rectangular, square or standard rod and wire sections, furnished in straight lengths. Shapes are usually made by extrusion but may also be fabricated by drawing.

Flat Product—A rectangular or square solid section of relatively great length in proportion to thickness.

a. **Plate**—A rolled flat product over 0.188 in. in thickness and over 12 in. in width.

b. **Sheet**—A rolled flat product up to and including 0.188 in. in thickness and over 20 in. in width.

c. **Strip**—A rolled flat product, other than flat wire, up to and including 20 in. in width, originally produced with slit, sheared or sawed edges, whether or not such edges are subsequently rolled or drawn.

d. **Rolled Bar**—A rectangular or square solid section up to and including 12 in. in width and over 0.188 in. in thickness, which is brought to final thickness by rolling and is furnished with sheared, sawed or machined edges.

Rod—A round, hexagonal or octagonal solid section. Round rod for further processing into wire (known as "hot-rolled rod," "wire-rod," or "redraw wire") is furnished coiled. Rod for other uses is furnished in straight lengths.

* *From ASTM Designations B224 and B248.*

Some Applicable ASTM Specifications

(The original specification should be consulted for details)

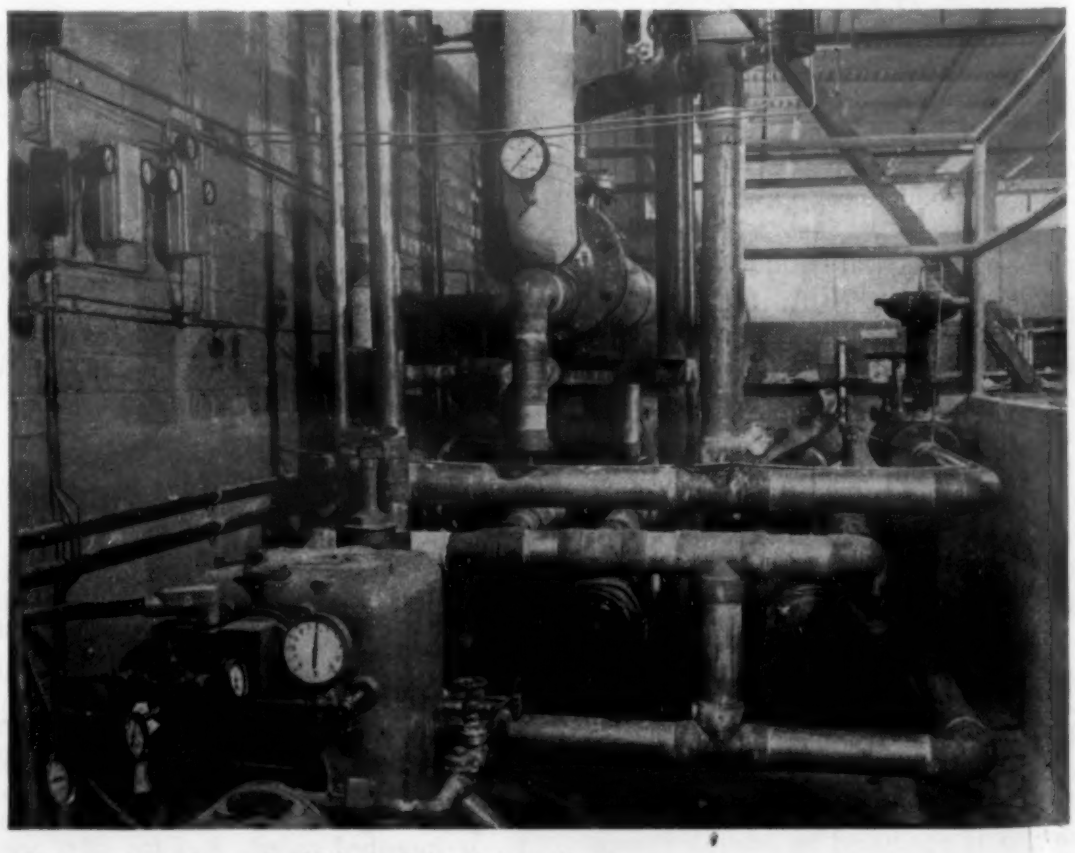
Designation	Flat Products	Rod, Bar and Shapes	Wire	Pipe and Tube
Electrolytic tough pitch (ETP)	B11, B152	B12, B49, B124, B133, B187	B1, B2, B3, B47, B48, B116, B272	B188
Fire-refined high conductivity tough pitch (FRHC)		B49, B124	B1, B2, B3, B47, B48, B116, B272	
Fire-refined tough pitch (FRTP)		B12, B133		
Arsenical, tough pitch (ATP)	B11, B152	B12, B133		
Silver-bearing tough pitch (STP)	B152	B124, B133, B187		B188
Silver-bearing arsenical tough pitch (SATP)*	B216	B216		B216
Selenium-bearing tough pitch (SETP)*	B216	B216		B216
Tellurium-bearing tough pitch (TETP)*	B216	B216		B216
Oxygen-free without residual deoxidants (OF)	B152	B12, B124, B133, B187		B13, B42, B68, B75, B188, B111
Oxygen-free, silver bearing (OFS)	B152	B124, B133, B187		B188
Oxygen-free, tellurium bearing (OPTE)*	B170	B170		B170
Phosphorized, high residual phosphorus (DHP)	B11, B152	B12, B124, B133		B13, B42, B68, B75, B111
Phosphorized, low residual phosphorus (DLP)		B12, B124, B187		B13, B42, B68, B75, B188, B111, B216
Phosphorized, silver bearing (DPS)	B152	B124, B133		
Phosphorized, arsenical (DPA)	B11	B12		B13, B75, B251, B111
Phosphorized, tellurium bearing (DPTE)*	B216	B216		B216

** Refinery Shapes.*

raises the softening (recrystallization) temperature and contributes some improvement in corrosion resistance toward specific environments. *Silver-bearing copper* is produced by adding silver to tough pitch, oxygen-free or deoxidized copper. Commercially, silver-bearing tough pitch is most readily available. The original silver-bearing copper was the product of mines on the Upper Peninsula of Michigan and was called Lake Copper. However, these mines are nearing exhaustion and silver-bearing copper (or synthetic Lake) is generally produced by adding silver to the coppers mentioned. Silver materially raises the softening temperature of copper without appreciably affecting electrical and thermal conductivity.

Tough pitch, oxygen-free and deoxidized copper have relatively poor machining characteristics in comparison with free-machining brass rod. For screw-machine and similar operations, all three of these coppers can be modified by the addition of certain elements which improve the machinability. The original free-machining copper contained about 1% lead which was added to deoxidized copper. However in recent years, leaded copper has been largely superseded by tellurium and selenium bearing copper, because these two coppers give free-machining characteristics with less adverse effect on fabricating properties.

The more readily available of these modified coppers have been classified by the ASTM in standard designation B-224 and are listed in a table. The table also includes several other coppers which have not been classified by the ASTM but contain at least 99% copper.



Copper piping is used widely in industrial applications.

Engineering Properties

Physical Properties

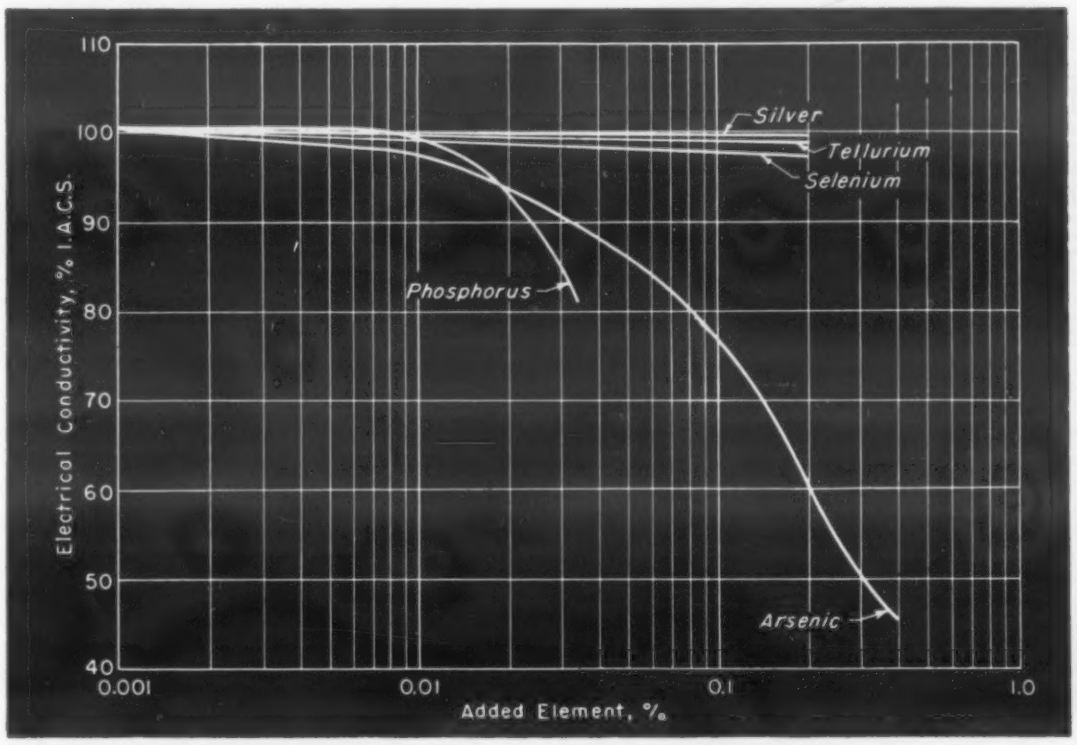
Probably the most important single physical property of copper is its electrical conductivity. A standard value for resistivity of annealed copper was adopted by international agreement in 1913. Conductivity values are based on this standard which has been assigned the value 100% International Annealed Copper Standard (I.A.C.S.), and other materials are rated in relation to this standard. Today, commercial electrolytic copper averages 101% IACS.

Copper which, in the annealed condition, has a minimum conductivity of 100% IACS is called high conductivity copper. As may be seen in the table, electrolytic tough pitch, oxygen-free, silver-bearing and boron deoxidized coppers fall within this classification. Phosphorized copper with low residual phosphorous (DLP) would also meet the requirement. These are the materials which receive first consideration for electrical applications. The conductivities of the remaining coppers range down to a low of 45% for those containing arsenic. Chromium copper, a precipitation hardening alloy, has an even lower conductivity before heat treatment but has a conductivity of about 80% afterward.

Thermal conductivity is roughly proportional to the electrical conductivity. All of these materials have approximately the same densities and thermal expansion coefficients. The modulus of elasticity is practically a constant for all of these materials excepting leaded copper, which has a lower modulus, and cadmium and chromium coppers, which have somewhat higher values.

Mechanical Properties

With the exceptions of chromium copper, the room temperature mechanical properties of the various coppers are closely related and they can be considered as a group. The tensile strength of annealed copper lies in the range 32,000 to 36,000 psi and elongation is above 40%.



Effect of certain elements on the electrical conductivity of copper (S. Skowronski, Private Communication).

Typical Physical Properties of Representative Coppers

Designation	Specific Gravity	Density, Lb/Cu in.	Elec Cond, % I.A.C.S. at 68 F	Ther Cond, Btu/Sq Ft/Ft/Hr/F at 68 F	Mod of Elast (Tension), Psi	Coef of Ther Exp per° F 68–570 F
Electrolytic tough pitch	8.91	0.322	101.0	226	17,000,000	9.8×10^{-6}
Phosphorized	8.94	0.323	85.0	196	17,000,000	9.8×10^{-6}
Oxygen-free	8.94	0.323	102.0	228	17,000,000	9.8×10^{-6}
Silver-bearing[1]	8.91	0.322	100.5	223	17,000,000	9.8×10^{-6}
Silver-bearing[2]	8.91	0.322	100.0	223	17,000,000	9.8×10^{-6}
Selenium copper	8.91	0.322	99.0	222	17,000,000	9.8×10^{-6}
Tellurium copper	8.94	0.323	98.0	221	17,000,000	9.8×10^{-6}
Arsenical copper	8.91	0.322	45.0	112	17,000,000	9.6×10^{-6}
Phosphorized arsenical	8.94	0.323	45.0	112	17,000,000	9.6×10^{-6}
Phosphorized tellurium-bearing	8.94	0.323	90.0	205	17,000,000	9.8×10^{-6}
Leaded copper	8.94	0.323	99.0	222	15,000,000	9.8×10^{-6}
Boron deoxidized	8.94	0.323	100.0	223	17,000,000	9.8×10^{-6}
Cadmium copper	8.89	0.321	87.0	199	18,000,000	9.8×10^{-6}
Chromium copper	8.89	0.321	40.0(80.0[3])	99(187[3])	19,000,000	9.8×10^{-6}

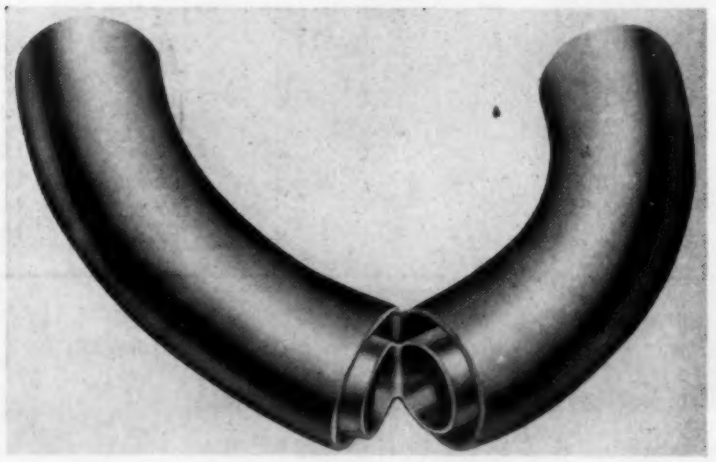
Notes:
[1] *10 to 15 oz/ton silver.*
[2] *25 to 30 oz/ton silver.*
[3] *After heat treatment.*

Typical Mechanical Properties of Representative Coppers

Designation	Form and Condition	Yld Str 0.5% Extension, Psi	Ten Str, Psi	Elong, % (2 in.)	Rockwell Hardness B	Rockwell Hardness F
Electrolytic tough pitch	Sheet 0.040 in., hard[1]	40,000–47,000	46,000–50,000	5–6	50–51	
	soft	8,000–10,000	32,000–33,000	35–45		35–40
	Rod 1 in. dia, hard[2]	40,000–45,000	45,000–48,000	15–16	47–50	
	soft	8,000–10,000	32,000	45–55		35–40
	Tube 1 in. dia by 0.065 in. wall, hard[2]	52,000	55,000	8	60	
	soft	8,000	32,000	45		40
	Wire 0.080 in. dia, hard[2]		66,000	1[3]		
	soft		35,000	35[3]		
Phosphorized	Sheet 0.040 in., hard[1]	45,000	50,000	5	50	
	soft	8,000	32,000	45		40
	Tube 1 in. dia by 0.065 in. wall, hard[2]	40,000–50,000	45,000–55,000	5–10	50–60	
	soft	8,000–10,000	32,000–35,000	45		40
Oxygen-free	Sheet 0.040 in., hard[1]	45,000	50,000	5	50	
	soft	8,000	32,000	40		40
	Tube 1 in. dia, hard[2]	51,000	53,000	3	56	
	soft	8,000	32,000	43		33
Silver-bearing[4]	Sheet 0.040 in., hard[1]	40,000–47,000	46,000–53,000	5	51–55	
	soft	7,000–10,000	32,000–33,000	35–40		35–40
Silver-bearing[5]	Sheet 0.040 in., hard[1]	40,000	46,000	5	51	
	soft	10,000	33,000	35		35
Selenium copper	Rod 1 in. dia, hard[2]	40,000	45,000	12	50	
	soft	10,000	32,000	45		35
Tellurium copper	Rod 1 in. dia, hard[2]	49,000	53,000	7	48	
	soft	7,000	32,000	40		40
Arsenical copper	Sheet 0.040 in., hard[2]	39,000	57,000	4	62	
	soft	5,000	34,000	44		41
Phosphorized arsenical	Tube 1 in. dia by 0.065 in. wall, hard[1]	40,000	60,000	4		95
	soft	8,000	37,000	42		28
Phosphorized tellurium-bearing	Rod 1 in. dia, hard[2]	45,000	47,000	10	41	
	soft	7,000	32,000	40		40
Leaded copper	Rod 1 in. dia, hard[2]	40,000	45,000	12	50	
	soft	10,000	32,000	45		35
Boron deoxidized	Rod 1 in. dia, hard[2]	40,000	45,000	15	50	
	soft	10,000	32,000	45		35
Cadmium copper	Sheet 0.040 in., hard[1]	48,000	55,000	6	65	
	soft	12,000	37,000	50		47
	Wire 0.080 in. dia, hard[2]		90,000	1[3]		
	soft		40,000	40[3]		
Chromium copper	Rod 1 in. dia, hard[2]	57,000	62,000	20	70	
	soft	15,000	35,000	40		50
	Rod 1 in. dia, heat treated[6]	61,000	72,000	25	77	
	heat treated[7]	45,000	63,000	25		65

Notes:

[1] *Hard sheet reduced approximately 37% by cold rolling.*
[2] *Rod, wire or tube of commercially hard drawn temper.*
[3] *Elongation in 10 in.*
[4] *10 to 15 oz/ton silver.*
[5] *25 to 30 oz/ton silver.*
[6] *Heat treated in hard condition.*
[7] *Heat treated in soft condition.*



Double pipe bend of phosphorized copper for the production of a condenser.

Copper as such can be hardened only by cold working. Full hard material has a tensile strength roughly twice that of the soft material. At the same time, elongation is reduced to less than 10%. Properties of representative coppers are included in a table.

Chromium copper, however, is quite different from the remaining coppers. It is a precipitation hardenable material and can be heat treated to considerably higher strengths and hardnesses than are obtainable with the other alloys in the group.

Low Temperature Properties

The coppers retain their ductility at low temperatures as measured by the impact test. They do not have a transition temperature from ductile to brittle behavior. As the temperature falls, there is some increase in strength and hardness and moderate stiffening. These materials are suitable for service to temperatures at least as low as —300 F.

Elevated Temperature Properties

In the application of coppers for moderately elevated temperatures, the temperature at which softening of hard worked copper becomes appreciable can be quite important. This temperature is a variable which depends on the degree of cold work. Softening temperatures of a number of commercial coppers are given in an accompanying table.

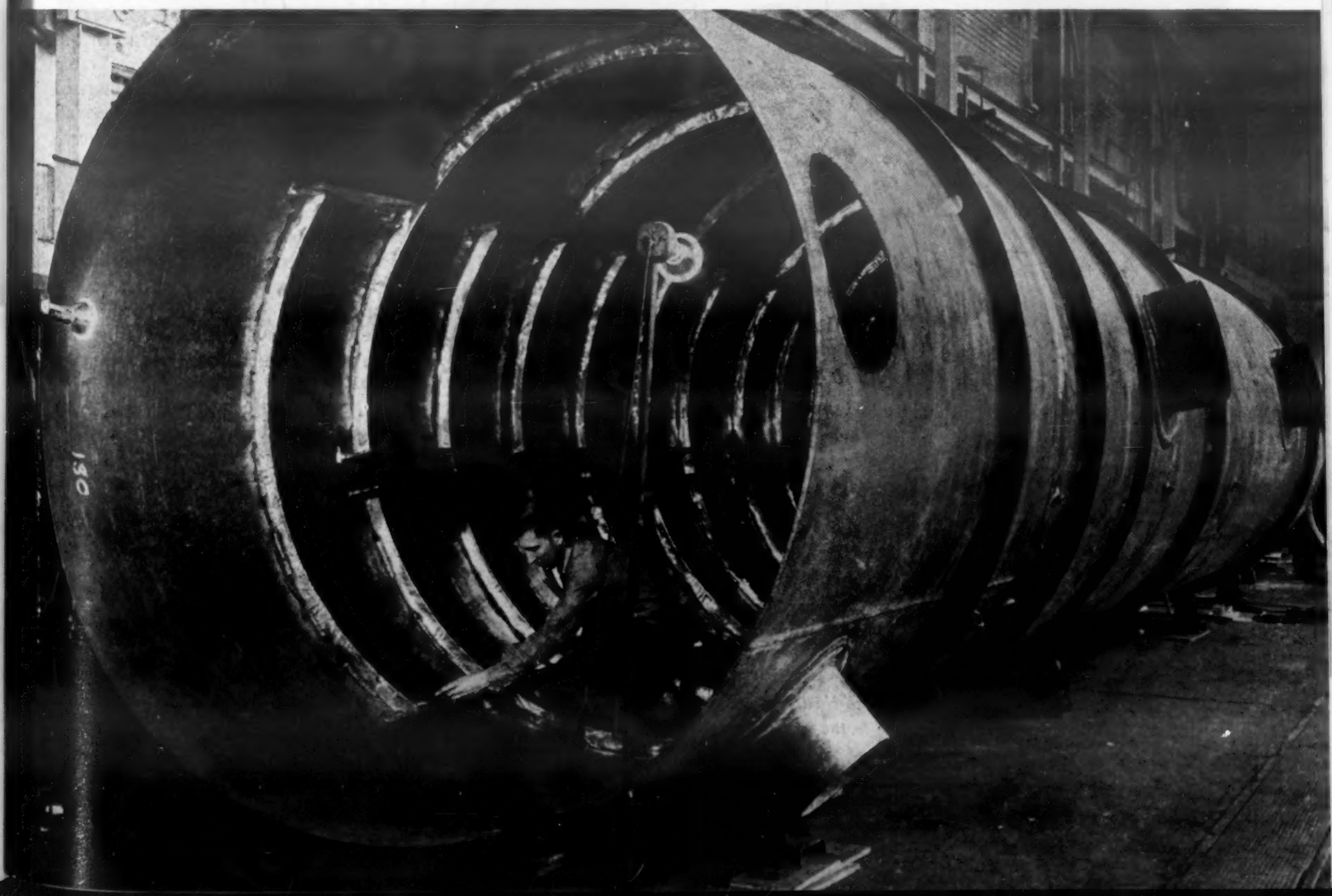
Softening is dependent on amount and type of impurities or alloying elements. Tough pitch copper softens at a lower temperature than the other commercial coppers because most of the impurities are in the oxidized condition and do not tend to restrain recrystallization. On the other hand, in oxygen-free copper, part of the impurities are present in solid solution, recrystallization is somewhat retarded and the softening temperature is raised. The addition of silver to copper tends to restrict recrystallization further and softening occurs at still higher temperatures. Thus 25 oz/ton silver (0.087%) increases the temperature range in which the material will retain its initial hardness by 200 to 300 F. Arsenic and phosphorous also raise the recrystallization temperature although the effect of phosphorous is not so great as that of silver or arsenic.

Effect of Silver on Softening Temperature
(Benson, McKeown and Mends)[3]

Designation	Temperature producing 50% softening in 1 hr after	
	50% reduction by cold-working	25% reduction by cold-working
Electrolytic tough pitch	435	465
Silver-bearing tough pitch[1]	645	690[2]
Oxygen-free	570	615
Silver-bearing oxygen-free[1]	650	680[2]

NOTES:
[1] *30 oz/ton silver.*
[2] *Extrapolated.*
[3] *Jour. Inst. Metals Vol. 80, 1951.*

Automatic welding methods have greatly improved the speed and quality of copper welds. This large fractionating column for the chemical industry was welded by the inert gas metal arc method using a mixture of helium and argon as the shielding gas.



Creep Properties of Some Coppers

(Burghoff and Blank)

Designation	Condition	Temp, F	Stress (Psi) for designated creep rate in 1000 hr		Source
			0.01%	0.1%	
Electrolytic tough pitch	Ann, 0.025 mm grain size	300	2,950	8,000	Proc. ASTM Vol. 47, 1947
		400	1,300	4,000	
		500	350	1,150	
	Drawn, 84% reduction	300	9,400	14,700[1]	
		400	2,100	4,350	
Phosphorized	Ann, 0.013 mm grain size	300	7,200	9,500	Trans. AIME Vol. 161, 1945
		400	2,100	5,400	
		500	700	1,950	
	Drawn, 84% reduction	300	21,000		
		400	5,200		
		500	600	2,300	
Oxygen-free copper	Ann, 0.025 mm grain size	300	3,600	8,200	Proc. ASTM Vol. 47, 1947
		400	1,500	4,800	
		500	400	1,700	
	Drawn, 84% reduction	300	8,300	12,800[1]	
		400	1,750	5,000	
Silver-bearing copper (10-15 opt silver)	Drawn, 84% reduction	300	30,000	30,000	Elect. Mfg. Sept., 1953
Phosphorized arsenical copper	Ann, 0.045 mm grain size	300	8,400	>10,000	Proc. ASTM Vol. 47, 1947
		400	5,200	> 7,000	
		500	2,600	5,500	
	Drawn, 84% reduction	300	40,000	46,000	
		400	27,500	35,500	
		500	2,000[1]	3,750[1]	

[1] *Produced accelerated creep rate.*

Copper plates being fabricated into a large fractionating column. The inert gas metal arc method of welding was used extensively in the production of this column.

The creep of copper is affected also by composition and in hard coppers, the higher softening temperature of silver bearing or arsenical copper markedly influences creep rate. This is shown also in a table. Electrolytic tough pitch and oxygen-free copper have the lowest creep strengths, followed by phosphorized copper while silver-bearing and arsenical coppers are highest in resistance to creep. For example, in one investigation it was found that silver-bearing tough pitch copper had the same creep strength at 440 F as electrolytic tough pitch copper had at 265 F. Silver-bearing and arsenical coppers are therefore used more widely in elevated temperature applications than the others.

Corrosion Resistance

There is not sufficient variation in the composition of these alloys to influence the corrosion resistance to any marked extent and they can be considered as a group.

Copper exhibits satisfactory resistance to the atmosphere and to sea water and is used extensively in environments of this nature. Copper is attacked rapidly by oxidizing acids such as nitric but resists sulfuric, hydrochloric and other non-oxidizing

acids. It is not suitable for service in contact with hydrocyanic acid and cyanides. Although it is satisfactory for handling sodium and potassium hydroxides, chlorides and sulfates, it is not recommended for service in contact with ammonium hydroxide and chloride. In general, copper is resistant to many other salts although it is not resistant to those which are readily reduced. Thus, it resists ferrous sulfate and chloride but is severely attacked by the corresponding ferric salts. Copper resists dry ammonia, but is severely damaged when moisture is present.

An estimate of the resistance of copper to a number of corroding media is included in a table. This table should be used only as a preliminary guide. The influence of such factors as rate of flow, purity of the solution, aeration and temperature are so great that no specific recommendations are possible. An actual test in the solution being evaluated is desirable. As an example, copper shows satisfactory resistance to boiling, dilute sodium hydroxide solution containing sodium salts but the introduction of air into the solution will greatly increase the rate of attack.

Approximate Corrosion Resistance of Copper

Good	Fair	Poor
Acetic acid	Ammonium sulfate	Acetylene
Alcohols	Chlorine, moist	Ammonia, moist
Ammonia, dry	Copper chloride	Ammonium hydroxide
Atmosphere, rural, industrial, marine	Copper nitrate	Ammonium chloride
Bleaching powder, wet	Hydrobromic acid	Ammonium nitrate
Boric acid	Hydrochloric acid	Chromic acid
Bromine	Hydrofluoric acid	Ferric chloride
Carbon dioxide	Phosphoric acid	Ferric sulfate
Chlorine, dry	Sodium hypochlorite	Hydrocyanic acid
Citric acid	Sodium peroxide	Hydrogen sulfide, moist
Copper sulfate	Sodium sulfide	Nitric acid
Ferrous chloride	Sulfuric acid (40–80%)	Potassium cyanide
Ferrous sulfate	Water, acid mine	Silver salts
Hydrogen	Zinc chloride	Sodium cyanide
Hydrogen sulfide, dry		Sulfur, molten
Natural gas		
Oxygen		
Potassium chloride		
Potassium hydroxide		
Potassium sulfate		
Sodium chloride		
Sodium hydroxide		
Sodium sulfate		
Sulfur dioxide		
Sulfuric acid (80–95%), (below 40%)		
Water, fresh or sea		

Good indicates usable under most conditions.
Fair indicates subject to attack but may be used under certain conditions.
Poor indicates unsuitable.

Processing Characteristics

Forming and Fabrication

Copper has excellent ductility and does not work-harden as rapidly as brass or bronze. Consequently, it is capable of being cold worked drastically with reductions up to 90%. Although the various grades have essentially similar cold working characteristics deoxidized and oxygen-free grades can stand somewhat more severe bending and forming operations than tough pitch copper.

For most press working operations involving cupping and drawing, copper is somewhat less ductile than 70-30 brass. However it has good formability and can be readily stamped, coined and embossed. The metal has excellent spinning properties, an annealed sheet with controlled grain size being used for best results. Bending and forming of cold rolled strip are influenced by the directional properties of the strip. Strip in cold rolled tempers can be bent more readily across the rolling direction than parallel to it and this factor must be considered when sharp bends are made. Soft, thin

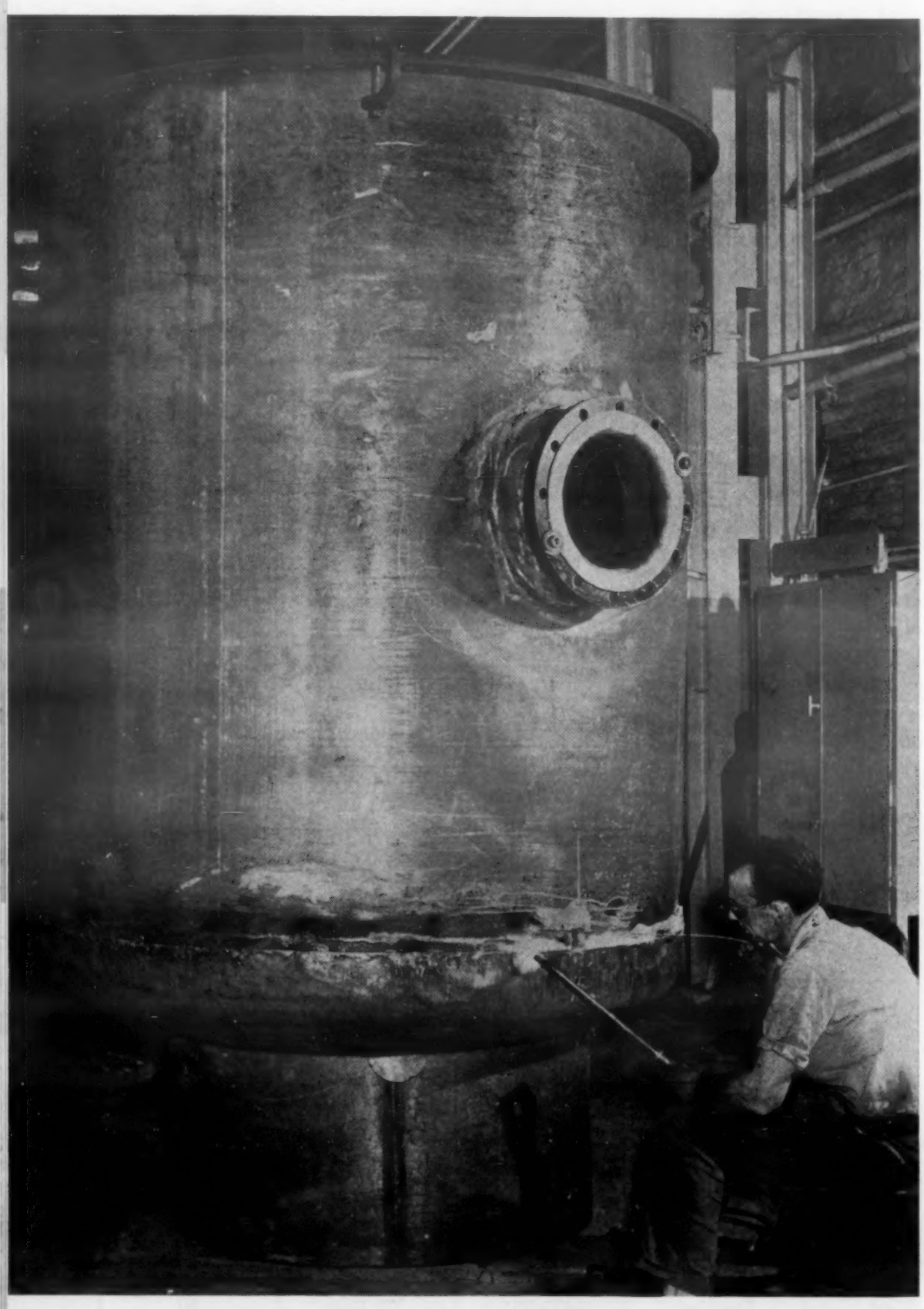
Fabricating Properties of Some Coppers

Designation	Cold Working	Hot Working	Hot Working Temp Range, F	Commercial Annealing Temp Range, F	Machinability Rating Free-cutting brass = 100
Electrolytic tough pitch	Excellent	Excellent	1400–1600	700–1200	20
Phosphorized	Excellent	Excellent	1400–1600	700–1200	20
Oxygen-free	Excellent	Excellent	1400–1600	700–1200	20
Selenium copper	Good	Excellent	1400–1600	700–1200	90
Tellurium phosphorized	Good	Excellent	1400–1600	700–1200	90
Leaded copper	Good	Poor	—	700–1200	80

Minimum Permissible Bending Radii For 0.020 in. Copper Strip (Gohn)*

Condition	Across grain	Bend at 45 deg to rolling direction	With grain
Cold-rolled 2 B & S Nos. Hard	1/32 in.	1/32 in.	3/64 in.
Cold-rolled 6 B & S Nos. Hard	1/64 in.	1/32 in.	1/32 in.

** Proc. ASTM Vol. 36, 1936.*



Joining a copper head to a shell by silver brazing.

material will stand more drastic bends than hard, thick material. Some idea of the minimum bending radii permissible for copper can be obtained from an accompanying table.

With the exception of leaded copper, all grades have excellent hot working properties. Hot bending and forming are used for bending heavy-wall pipe, dishing heavy plates for pressure vessel heads and similar operations which can be performed more readily hot than cold.

These materials are hot forged and pressed at temperatures of 1400 to 1650 F. Of the group, electrolytic tough pitch and phosphorized coppers are most widely used for this purpose.

Heat Treatment

The principal function of heat treatment as applied to the coppers is annealing preparatory to further cold working. Commercial annealing temperatures range from 700 to 1200 F, selection being based on grain size desired. The lower the annealing temperature the finer the grain.

Chromium copper, however, is a precipitation hardening copper. By suitable treatment, considerable increase in strength and electrical conductivity can be achieved. Heat treatment is performed in two stages. The first is a solution treatment of about 1750 F for ½ hr followed by water-quenching. The second is an aging treatment at about 850 F for 4 to 8 hr depending on size. Some results of such treatment are included in the tables on physical and mechanical properties.

Machining

There is no simple method of comparing the machinability of metals since there are so many possible combinations of speed, feed, and depth of cut but some indication of practical procedures can be given.

The machinability of free-cutting yellow brass is commonly assigned the arbitrary rating of 100%. On this basis, commercially pure copper is rated 20% and falls within the classification of materials which are relatively difficult to machine. Some authorities consider that tough pitch copper is slightly more machinable than oxygen-free or phosphorized and assign tough pitch a rating of 25%.

In turning operations, ductile metals like copper require relatively large rake angles. In fact, side rakes

Suggestions for Machining

Operation	Speed-surface Ft/min[a]		Feed, in./rev		Tool angles, deg	
	Copper[b]	Free-cutting[c]	Copper	Free-cutting	Copper	Free-cutting
Turning	75–150	300–700	Roughing 0.015–0.040 Finishing 0.003–0.015	Roughing 0.006–0.020 Finishing 0.003–0.015	Side rake 20–30 Back rake 10–20 Side clearance 10–20 Front clearance 10–15	Side rake 0–3 Back rake 0 Side clearance 0–5 Front clearance 6
Parting			0.0005–0.0015	0.0005–0.0015	End cutting edge 25 Back rake 7–15 Side clearance 2–4 Front clearance 5–10	End cutting edge 15 Back rake 0 Side clearance 2–4 Front clearance 5–10
Milling	50–100	200–250	0.5–20[d]	0.5–20[d]	Rake 0–15 Clearance 12–15	Rake 0–10 Clearance 10–15
Drilling	50–125	200–500	0.003–0.020	0.003–0.020	Standard twist drill, full rake angle, cutting edge not flattened.	Standard twist drill, 0 deg rake angle, 6–8% of cutting edge flattened.

[a] For regular high speed steel tools, reduce for carbon steel tools, increase, in general for carbide tools.
[b] All types of copper excepting the free-cutting grades.
[c] Includes leaded copper and coppers containing tellurium or selenium.
[d] Depends on such factors as cutter width, machine rigidity, and finish desired.

for copper frequently exceed those generally used for steel. Suggested values are given in a table. Cutting edge angles vary depending on the nature of the machining operation.

Standard straight-blade cut off tools and many types of commercial milling cutters are satisfactory for copper. A coarse tooth spiral cutter with 20 to 30 deg helix angles or a helical cutter with a 50 deg angle produces a fine surface on copper when suitable rake and clearance angles are used. The clearance angle should be greater for large than for small cutters, the maximum angles shown in the accompanying table being suitable for cutter diameters of 3 to 4 in.

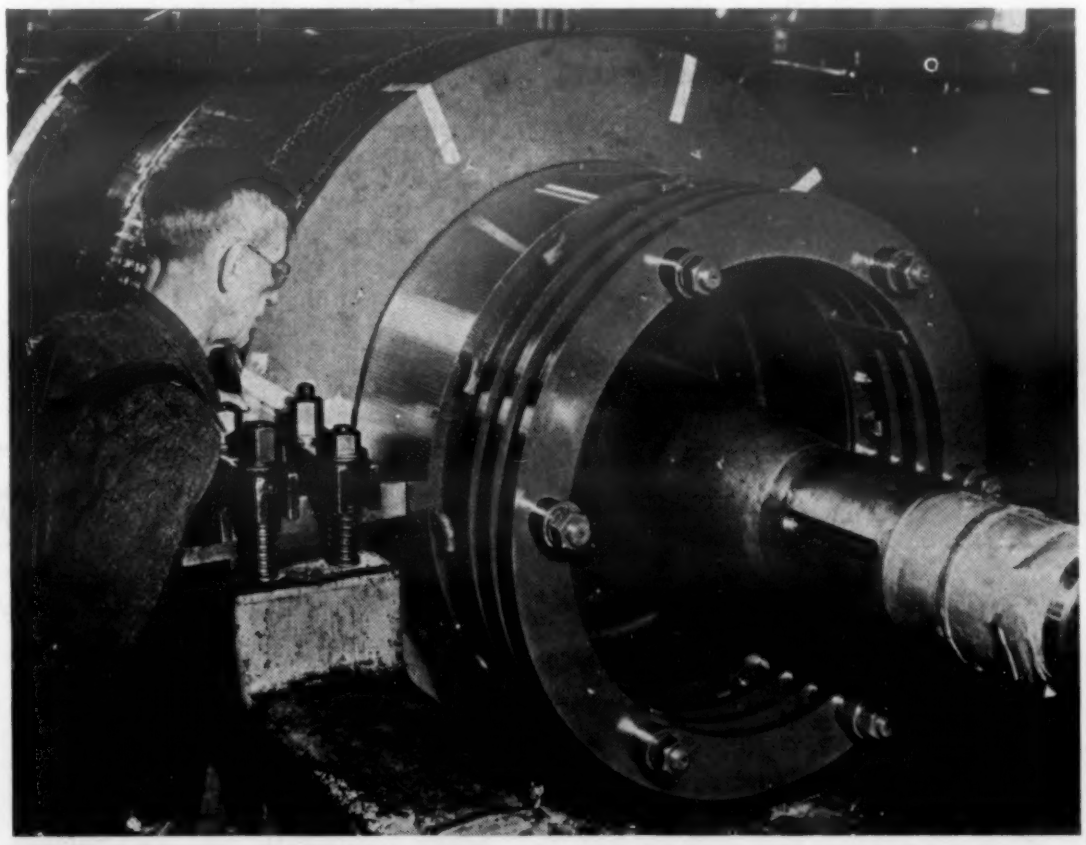
Standard twist drills are satisfactory for copper if the full rake angle is employed. Drills of special design are in use for long run production operations. These drills have a greater number of twists per inch, the increased rake angle resulting assists in removal of the chips.

In machining copper ample cooling is required for best results. The function of this material is lubrication as well as cooling. Mineral oil containing from 20 to 30% lard oil is used extensively for the purpose. Sulfurized mineral oil has been used but parts must be cleaned as soon as possible after machining to avoid discoloration caused by the sulfur.

These suggestions apply to most of the coppers under discussion. There is, however, a special group containing lead, selenium or tellurium. Addition of these elements to copper greatly improves the machinability and as a result, these modified coppers have a machinability rating of 80 to 90% and are classified as free-cutting coppers. They are used particularly in screw machine operations. Suggested conditions for machining these coppers are included also in a table. It is possible to use the same tooling as is used for free-cutting brass.

Cooling and lubrication of these coppers is frequently accomplished by flooding the material with paraffin oil particularly when machining speeds are high. A light feed and moderate depth of cut are employed. A mixture of 20 parts water to 1 part soluble oil is also used.

The choice of a tool material depends on the service requirements. For short runs at relatively low speeds, carbon steel cutters can be used. On moderate production runs, high speed steels are employed especially for turning tools because the



The excellent conductivity of tough pitch copper leads to wide applications in the electrical industry.

Fabricating a phosphorized copper kettle by the inert-gas metal arc welding process.

speed of cutting can be increased. Carbide tools are frequently used for long runs particularly where quantity of metal to be removed is extensive.

Joining

The coppers can be joined by soldering, brazing or welding but certain characteristics must be recalled to obtain satisfactory results, particularly in welding. The high thermal conductivity offers a problem in heavy sections because of the rapid removal of heat from the immediate joint area. The heat affected zone is wider for copper than for other metals. The high electrical conductivity also introduces problems particularly in resistance welding.

With the exception of soft soldering, joining tough pitch copper introduces problems not encountered with oxygen-free or deoxidized coppers because of presence of cuprous oxide, which is readily reduced if heated at elevated temperatures in reducing atmospheres. Thus, the coppers must be divided into two groups in a discussion of their welding characteristics particularly. Relative ease of joining the coppers is indicated in a table and methods are discussed briefly in the following sections.

Soldering and Brazing—Soldering and brazing are operations in which the parent metal is not raised to its melting point. They are thus distinguished from welding. Copper can be readily soft soldered and brazed. If suitable precautions are taken to prevent contact of tough pitch copper with reducing gases at brazing temperatures, all of the coppers can be treated alike.

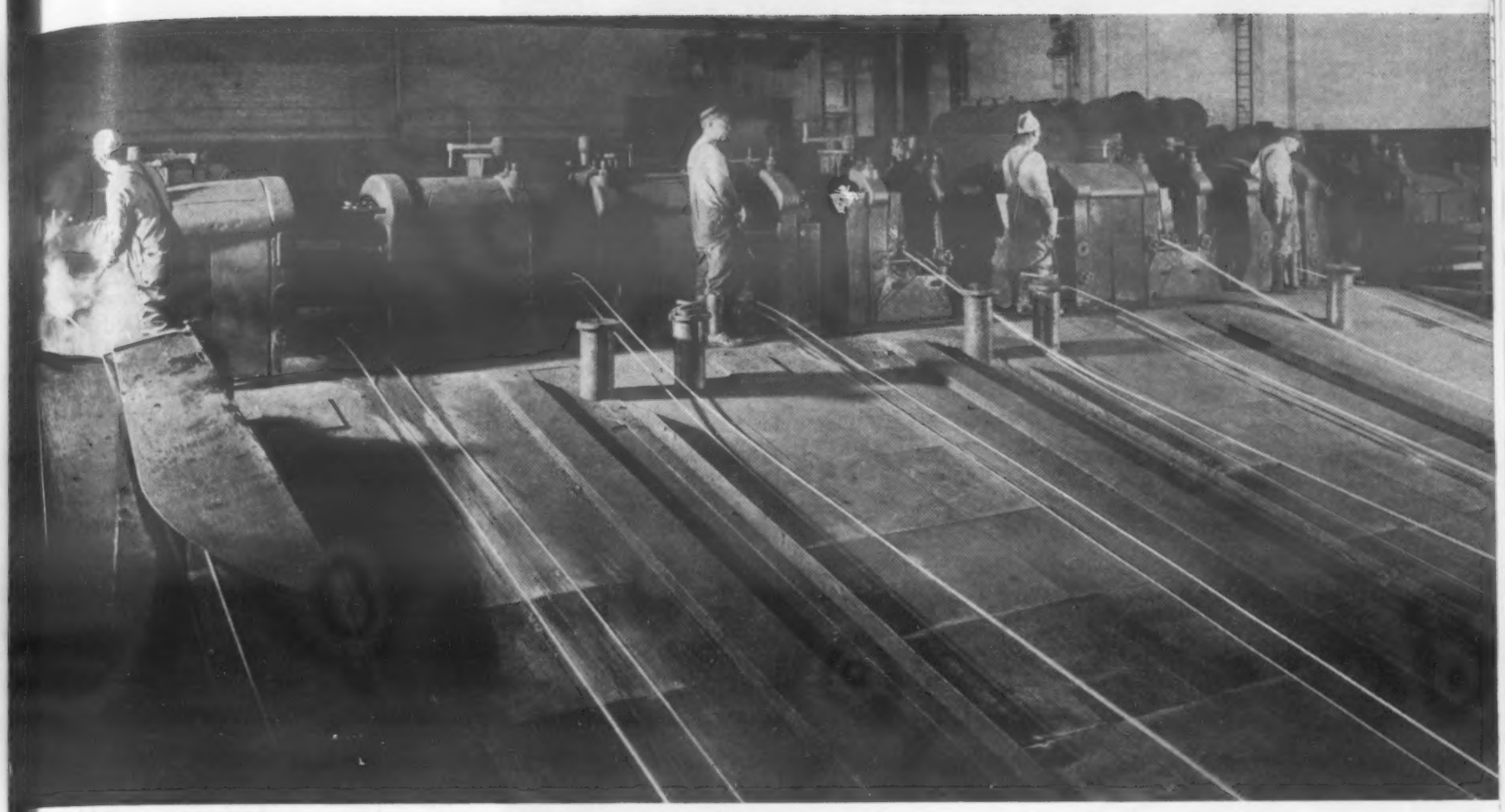
Soft soldering implies joining with metals which melt below 800 F while brazing implies the use of alloys melting above this temperature. Hard soldering, silver soldering and silver brazing are used interchangably for joining with alloys of high silver content. The use of brass for joining is generally called brass brazing.

Soft solders, which are chiefly lead-tin alloys, are employed widely in joining copper. There are no particular problems involved except the ordinary precautions of having the metal surfaces clean and free from greases. As a matter of fact, copper is probably the easiest metal to join by soft soldering. If the surface is free of oxides, mild fluxes of the rosin type can be used. If oxide removal is necessary, a mixture of zinc and ammonium chloride or one of the proprietary activated fluxes may be required. Soft solders standardized by ASTM are covered in Specification B32 which has an appendix giving suggested applications for each grade.

Standard brazing procedures are applicable to copper, and any method of heating which will quickly raise the material to brazing temperature

Joining Properties of Some Coppers

	Soft Soldering	Brazing	Oxy-acetylene Welding	Carbon arc Welding	Metal arc Welding	Inert-Gas arc Welding
Electrolytic tough pitch	Excellent	Good	Poor	Fair	Fair	Fair
Phosphorized	Excellent	Excellent	Fair	Good	Good	Excellent
Oxygen-free	Excellent	Excellent	Fair	Good	Good	Excellent
Selenium copper	Good	Fair	Poor	Poor	Poor	Good
Tellurium phosphorized	Good	Fair	Poor	Poor	Poor	Good
Leaded	Good	Fair	Poor	Poor	Poor	Poor



Series of operations during the hot rolling of rod preparatory to drawing wire for use in cables and telephones.

can be used. To develop a joint strength equivalent to that of annealed copper it is customary to use a lap joint in which the lap is three times the thickness. Copper-phosphorus and copper-phosphorus-silver brazing alloys can be used without fluxes. Silver brazing alloys require a suitable flux. These alloys melt in the range 1150 to 1600 F. Copper-zinc alloys are sometimes used for brazing copper although higher temperatures are required. Standard brazing alloys are given in ASTM specification B260 which includes also an appendix suggesting applications of the various grades.

Carbon-arc Welding—Because of the cuprous oxide content, tough pitch coppers are difficult to weld by the carbon-arc process. The reducing atmosphere in the weld area causes embrittlement, the degree depending on time of contact with the gases at welding temperature. Best results are obtained by using d-c straight polarity, phosphor bronze welding rods with a flux consisting of fused borax and sodium fluoride and a lineal speed of 10 to 20 in. per min. This procedure is limited to material not more than $\frac{3}{8}$ in. thick.

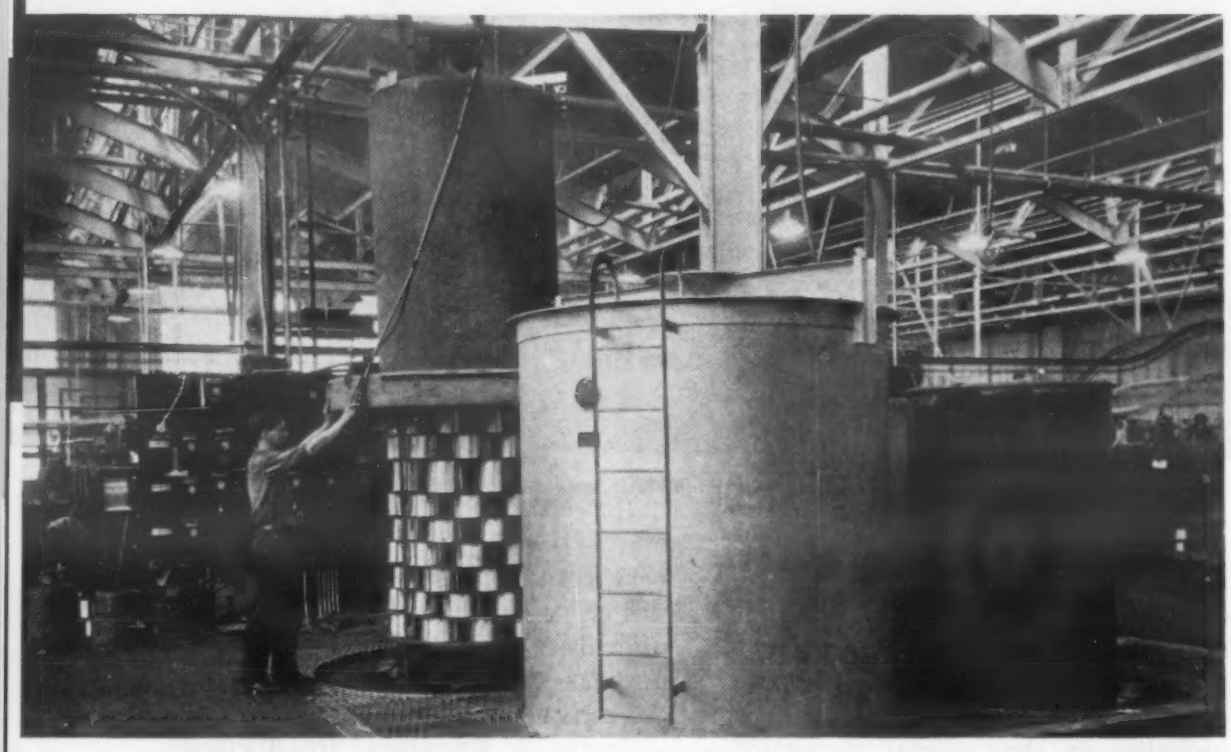
Oxygen-free and deoxidized coppers are more readily welded by this process. Straight polarity d-c is used. Copper-silicon welding rods with suitable fluxes are most successful and multiple pass welding permits the joining of all thicknesses. These welding rods contain 99.75% copper and 0.25% silicon, but have not been included in the general discussion because of their specialized nature. The effect of lineal speed is apparent only in the density. Welding must be done in the flat position and a backing of copper is necessary. Phosphor bronze welding rods without flux can be used for single pass welds on thicknesses up to $\frac{3}{8}$ in.

Metal-Arc Welding—Properties of the joint dictate the choice of electrodes used in shielded metal-arc welding. If high conductivity and corrosion resistance are necessary, deoxidized copper electrodes must be used. Under less critical service conditions, phosphor bronze or copper silicon electrodes are used to take advantage of the lower preheating and interpass temperatures which are required. Because of the high thermal conductivity of copper, preheat temperatures of 800 to 1000 F are necessary particularly in heavy sections. Higher amperage and larger electrodes are used than would be required for steel of the same thickness. The process is suitable for oxygen-free and deoxidized copper, but, although not generally recommended for joining tough pitch coppers, can be used successfully by skilled operators. Certain practical difficulties make this method less popular than the inert-gas-shielded arc method.

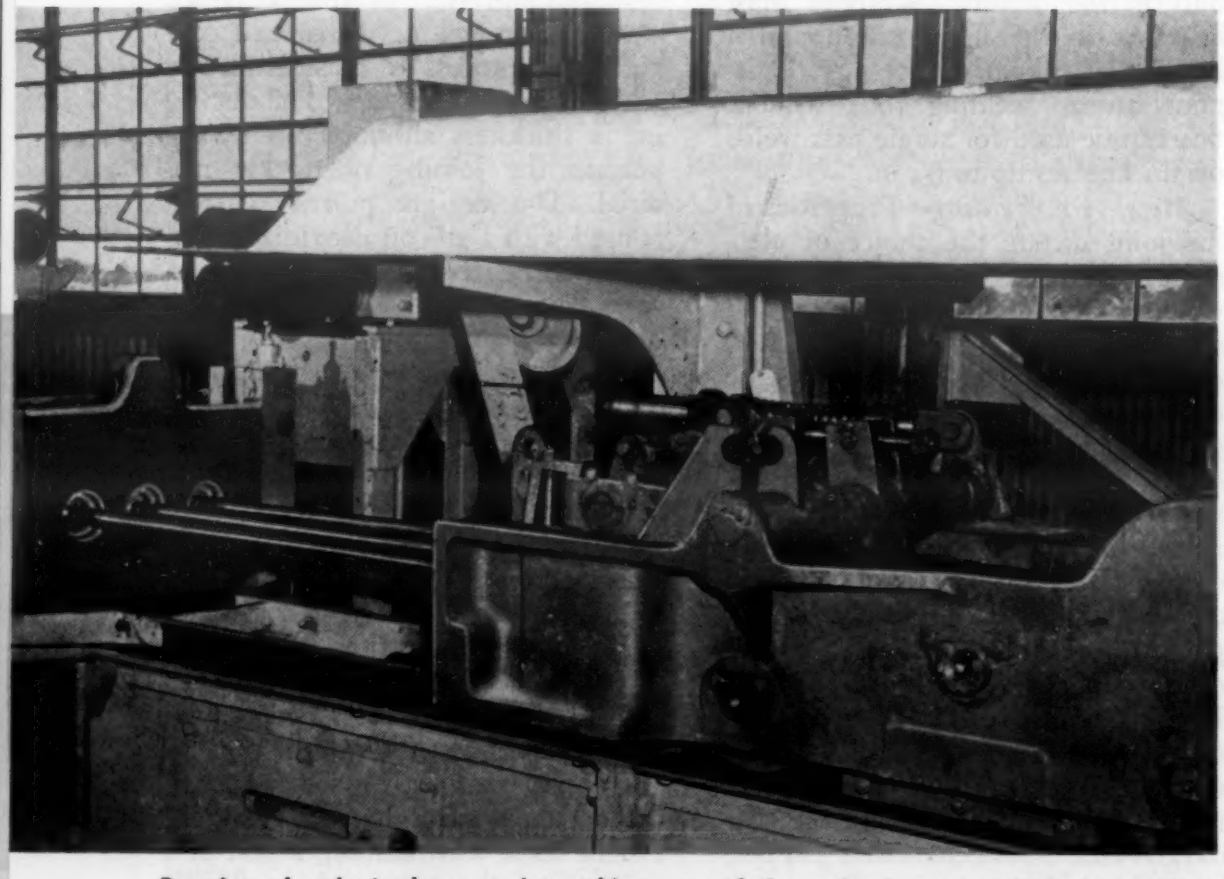
Inert-Gas Tungsten Arc Welding—Tough pitch copper can be welded by this process but joint strength is definitely inferior to that obtained with oxygen-free or deoxidized copper. The process is considered best for joining copper up to about $\frac{1}{4}$ in. in thickness although preheating permits the joining of thicker material. D-c straight polarity current is used with a silicon deoxidized copper welding rod. No flux is necessary. The shielding gas can be argon, helium or a mixture of the two.

Inert-Gas Consumable Electrode Welding—As is the case with the tungsten arc process, joint strength obtained with tough pitch copper is inferior to that obtained with deoxidized copper. The process is best suitable for joining material which is at least $\frac{1}{8}$ in. thick. The lighter gages must be welded against a backing plate. Sections greater than about $\frac{1}{2}$ in. in thickness will require some preheating; d-c reverse polarity current is used with a silicon deoxidized copper filler metal. Shielding can be done with helium, argon or a mixture of the two, and no flux is required.

Battery of wire-drawing machines used in the production of copper wire for electrical applications.



Bright annealing copper wire in a bell type furnace.



Drawing phosphorized copper into tubing, one of the major forms in which this grade is used.

Gas Welding—For gas welding the coppers, the oxyacetylene flame is used because of its high heat output. In welding tough pitch coppers, an oxidizing flame is required, and the filler metal is usually a high zinc brass and a flux is necessary. The process is also called braze-welding. Joints are inferior to those obtained when deoxidized copper is used.

Oxygen-free and deoxidized coppers can be welded using a neutral flame. Filler rods of deoxidized copper are used if high conductivity is necessary or maximum resistance to corrosion is required. However, both phosphorus or silicon deoxidized filler metal rods are widely employed. Preheating is generally necessary in joining heavy sections and welding can be done in the flat or vertical position. Fused borax and boric acid is generally used as a flux. The phosphorus deoxidized rods give better color match while silicon deoxidized rods yield sounder joints.

Resistance Welding—Joining of the coppers by spot, seam or projection welding is extremely difficult. Special techniques, such as use of electrodes faced with high-resistance materials can be used on thin sections. Butt welding is practiced widely, particularly in the production of rod and wire. High energy input and short welding time yield satisfactory joints with strengths equal to the parent metal.

Surface Finishing

Mechanical and Chemical Cleaning—Oils, greases, dirt or metallic particles picked up on the surface during fabrication can be removed by a variety of mechanical and chemical cleaning methods. The choice usually depends on size and quantity of parts to be handled and nature of the soil.

Small parts can be cleaned by abrasive tumbling. Burrs resulting from previous machining operations, grease and dirt can be removed by this process, which may also work-harden the surface. Tumbling can be followed by ball burnishing to improve surface appearance. Large pieces can be cleaned by blasting. Since copper is a relatively soft metal sand is preferred to steel or other hard shot for this operation. Wet blasting with a suspension of abrasive in water is increasing in popularity because considerable control of the intensity of the action is possible. Wet blasting has been used not only to deburr and degrease the surface

but also to remove the excess flux resulting from soldering or brazing operations. After blasting, the work has a matte finish which can be used frequently with no further finishing operations.

Most widely used of chemical cleaning methods is alkali cleaning. Usually the bath consists of a proprietary mixture of caustic soda, phosphates, silicates, and similar alkalis with organic emulsifiers and synthetic wetting agents. There is some disagreement whether these compositions can be used indiscriminately for cleaning copper without excessive attack. Generally the bath is agitated to loosen the dirt while the alkali removes oils and greases by saponification or emulsification. Solutions frequently contain from 4 to 8 oz per gal of cleaner and the baths operate in the range 170 to 190 F.

Alkali cleaners are used also in electrolytic cleaning processes for which no emulsifiers or wetting agents are required. The work can be made either anode or cathode although the process is often operated in two stages. In the first, the work is made the cathode to obtain a rapid evolution of gas from the surface for quick cleaning. For this stage 4 to 6 oz per gal of cleaner can be used with an operating temperature of 160 to 200 F. After rinsing, the work is transferred to a second bath in which it is made the anode. Concentration of cleaning compound ranges from 4 to 12 oz per gal and the operating temperature is the same as in the first stage. In this cleaning cycle, most of the soil is removed during the first stage of the operation and second solution remains relatively free from oil and grease. Copper is tarnished readily during alkali cleaning. The film can be removed by dipping into dilute hydrochloric or sulfuric acid, rinsing in water and drying.

Solvent cleaning is often used on small parts such as screw machine products to remove cutting oil. The material is immersed in a suitable solvent usually a low boiling mineral oil fraction which is held at a temperature of 120 to 140 F. Only physical cleanliness is obtained by solvent cleaning. If chemical cleanliness is necessary for subsequent finishing operations, alkali cleaning must follow.

Vapor degreasing, usually with trichlorethylene as a solvent, is a rapid method of removing oils from the surface of a part. The material to be cleaned is placed in a suitable chamber in which the solvent vapor is condensed. The condensate removes the oil from the surface and leaves the material clean and dry.

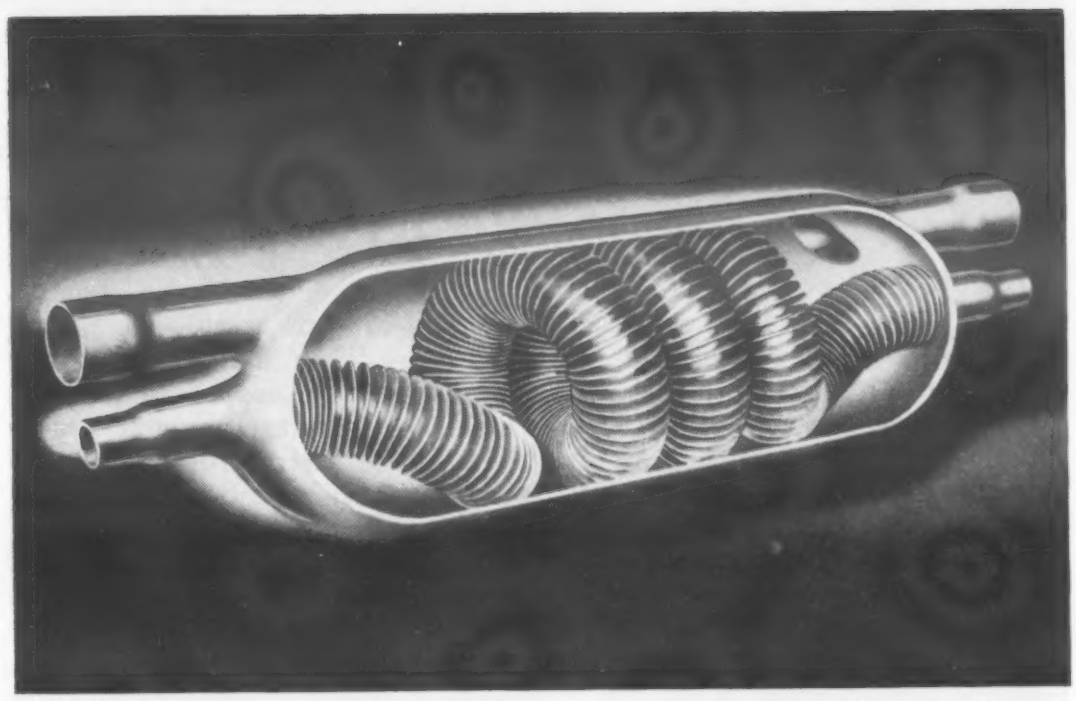
Pickling—When copper is annealed in an oxidizing atmosphere a surface film is formed. This film contains cupric, and cuprous oxides of copper. While cupric oxide is soluble in sulfuric acid, the lower oxides are not. Therefore, in cleaning the surface by pickling, it is necessary to add an oxidizing agent to the usual sulfuric acid bath employed in pickling copper alloys of lower copper content. The oxidizing agent can be sodium dichromate and the bath can be operated in the range from room temperature to about 175 F. Pickling leaves the surface free from oxide but with a dull finish. A bright surface can be obtained by following pickling with a bright dip.

Bright dip solutions are composed of mixtures of sulfuric and nitric acid to which a small quantity of water and hydrochloric acid are added. The hydrochloric acid brightens the surface but an excess may leave it spotty. The bath is maintained at room temperature usually by some method of cooling the tank to remove the heat reaction. Sodium chloride can be used to replace the hydrochloric acid. After bright dipping, the part is rinsed in water, dipped into a solution containing from about 4 to 8 oz per gal of sodium cyanide, rinsed in water and dried. A dip into a sulfuric acid-nitric acid-zinc sulfate solution held at 180 F can be used to obtain a matte finish after bright dipping. Rinsing in water and drying follow.

Plating—The excellent corrosion resistance of the coppers to many environments makes it unnecessary to protect the surface for most industrial applications. For some applications, however, primarily for decoration, copper is plated. Provided the surface is clean and free from greases and oils, copper is possibly the easiest metal to plate. Metals such as gold, silver, nickel and chromium are readily deposited by electroplating. Replacement coatings of silver, gold and tin are obtained by immersing the part to be plated in a suitable solution.

In architectural applications it is sometimes desirable to color copper; by immersion in solutions of suitable chemicals, various colors can be developed. These include black, reddish brown, bronze and a green which resembles the natural patina formed when copper weathers in air. To preserve the finishes obtained, lacquering is required.

Rotor for a fractional horsepower motor after welding by the carbon arc process.



Phosphorized copper heat exchanger consisting of a spun copper shell and finned tubing shows the ductility of this type of copper.

Applications

The factors underlying the majority of applications of the coppers are high electrical conductivity, high thermal conductivity, good strength, corrosion resistance, and ease of working and joining. A long list of applications could be cited but would serve no particular purpose. The following brief notes indicate the general field of usage of the various types but is illustrative rather than comprehensive.

Electrolytic tough pitch is the most widely used of all coppers. In electrical applications, it is used in motor, generator, transformer, and instrument windings, bus bars, contacts, household and industrial wiring and radio parts. Industrial applications based on the corrosion resistance thermal conductivity, or both, include chemical plant equipment, such as kettles, stills and pans, food processing equipment, molds and mold-stools for casting metals, printing rolls and expansion joints. In architecture, applications include roofing, spouting, screening, nails and rivets. This grade is used also in the automotive industry in various applications including automobile radiators.

In electrical applications, oxygen-free copper can serve for the same purposes as tough pitch but is usually selected for special applications for which tough pitch is unsuitable. This includes electrical equipment for service at elevated temperatures in the presence of reducing gases. Oxygen-free copper can be joined by hydrogen brazing and this factor leads to the application of a special certified grade in electronic applications. The discovery that copper oxide adheres more firmly to oxygen-free copper than to either tough pitch or phosphorized coppers resulted in the development of the Housekeeper glass-to-metal seal now widely used in electronics.

Although one grade of phosphorized copper is employed in electrical applications such as bus tubing and terminals for electrical appliances, most phosphorized copper is used for other purposes. Since it can be more severely worked than tough pitch copper and is more readily welded, phosphorized copper is widely used for the fabrication of equipment. Among major applications are industrial condensers, refrigerators, heat exchangers and evaporators, and the fabrication of welded vessels. Domestic usage includes refrigerator lines, plumbing pipe and tubing and oil burner tubing.

Silver-bearing copper is used also for electrical commutators, electric motors for aircraft and railroad service and for moderately elevated temperatures where its strength retention is advantageous. Because its softening point is above the melting point of the usual soft solders, silver-bearing copper can be soldered in the hard condition with no loss in strength. This property is advantageous in the production of such equipment as special types of radiators for internal combustion engines.

Like silver, arsenic raises the recrystallization temperature of copper but unlike silver it reduces the electrical conductivity drastically. It is not used therefore in applications in which conductivity is a major requirement. Arsenical copper is employed more extensively in Europe than in the United States for such applications as the fabrication of equipment to be used at elevated temperatures including locomotive fireboxes.

Tellurium-bearing copper is used for screw machine products, torch tips and electrical application such as switch parts, contact points, relays, bolts, studs and soldering tips. Cadmium copper is used for trolley wires and resistance welding electrodes. Chromium copper applications include spot and seam welding electrodes, also parts in electrical equipment requiring a combination of high hardness of strength with good electrical conductivity.

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The Scomet Co.
The Vulcan Copper and Supply Co.
Western Electric Co.
Westinghouse Electric Corp.
Wolverine Tube Div.

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Materials Engineering File Facts

MATERIALS & METHODS
December • 1953
Number 265

Carbon Molybdenum Steels—Materials Data Sheet

AISI TYPE	4023	4032	4042	4053	4063
COMPOSITION, %	C 0.20/0.25 Mn 0.70/0.90 P 0.040 max S 0.040 max Si 0.20/0.35 Mo 0.20/0.30	C 0.30/0.35 Mn 0.70/0.90 P 0.040 max S 0.040 max Si 0.20/0.35 Mo 0.20/0.30	C 0.40/0.45 Mn 0.70/0.90 P 0.040 max S 0.040 max Si 0.20/0.35 Mo 0.20/0.30	C 0.50/0.56 Mn 0.75/1.00 P 0.040 max S 0.040 max Si 0.20/0.35 Mo 0.20/0.30	C 0.60/0.67 Mn 0.75/1.00 P 0.040 max S 0.040 max Si 0.20/0.35 Mo 0.20/0.30
PHYSICAL PROPERTIES					
Density, Lb/Cu In.	0.283	0.283	0.283	0.283	0.283
Thermal Cond, Btu/Hr/Sq Ft/Ft/F @ 212 F	27	27	27	27	27
Coeff of Exp per F:					
70-1200	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}
Spec Ht, Btu/Lb/F:	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elect Res, Microhm-Cm @ 68 F:	19	19	19	19	19
Magnetic Properties	Magnetic	Magnetic	Magnetic	Magnetic	Magnetic
MECHANICAL PROPERTIES					
Mod of Elast in Tension, Psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Tensile Str, 1000 Psi:					
Annealed, cold drawn	88	92	96	102	109
Cold Drawn	90	104	117	127	137
Hard and Temp (see notes)	120[a] 108[b]	210[e] 140[d]	235[e] 158[f]	250[g] 165[h]	269[i] 173[j]
Yield Point, 1000 Psi:					
Annealed, cold drawn	76	79	82	88	94
Unannealed, cold drawn	75	89	101	108	115
Hard and Temp	85[a] 64[b]	182[c] 128[d]	210[e] 140[f]	223[g] 150[h]	231[i] 150[j]
Elong in 2 In., %:					
Annealed, cold drawn	22	20	19	18	16
Unannealed, cold drawn	21	17	16	14	13
Hard and Temp	20[a] 21[b]	11[c] 18[d]	10[e] 15[f]	12[g] 16[h]	8[i] 13[j]
Red of Area, %:					
Annealed, cold drawn	57	54	53	51	48
Unannealed, cold drawn	55	51	49	45	40
Hard and Temp	53[a] 54[b]	49[c] 63[d]	42[e] 60[f]	40[g] 56[h]	15[i] 40[j]
Hardness, Bhn:					
Annealed, cold drawn	179	192	202	212	223
Unannealed, cold drawn	183	217	241	262	277
Hard and Temp	255[a] 229[b]	415[c] 302[d]	461[e] 302[f]	495[g] 352[h]	534[i] 380[j]
Fatigue Str (End Limit), 1000 Psi	Fatigue properties are proportional to the tensile strength in the same ratio as other low alloy steels. At hardness values below 400 Brinell, the ratio is about 50%, at higher hardness levels it is about 45% of the tensile strength.				
THERMAL TREATMENT					
Annealing Temp, F	1650 [k]	1550–1600 [l]	1525–1575	1450–1550	1450–1550
Hardening Temp, F (oil-quench)			1500–1575	1475–1550	1475–1550
Tempering Temp, F	To desired properties				
FABRICATING PROPERTIES					
Machinability Index (B1112 steel=100)	73	70	65	56	52
Weldability:					
Elect Res	Can be welded by the procedures used for carbon steels. Molybdenum increases the hardenability and preheating or post-heating may be required.				
CORROSION RESISTANCE	The corrosion resistance of these steels is similar to that of the carbon steels.				
USES	Automotive parts such as countershafts, transmission shafts, spline and differential gears.	Automotive transmission gears and pinions, bolts.	Leaf and coil springs, bolts, axles, steering arms and knuckles. Hand tools such as screw drivers.		Leaf and coil springs. Hand tools such as chisels.

[a] *1 in. round pseudo-carburized at 1700 F, 8 hrs, oil-quenched, tempered 1 hr at 300 F.*
[b] *1 in. round pseudo-carburized at 1700 F, 8 hrs, oil-quenched, tempered 1 hr at 300 F; reheat 1475 F, oil quenched.*
[c] *Water quenched from 1525 F, tempered at 600 F.*
[d] *Water quenched from 1525 F, tempered at 1000 F.*
[e] *Oil-quenched from 1500 F, tempered at 600 F.*
[f] *Oil-quenched from 1500 F, tempered at 1000 F.*
[g] *Oil-quenched from 1475 F, tempered at 600 F.*
[h] *Oil-quenched from 1475 F, tempered at 1000 F.*
[i] *Oil-quenched from 1450 F, tempered at 600 F.*
[j] *Oil-quenched from 1450 F, tempered at 1000 F.*
[k] *Carburize 1650-1700 F, quench fine grained steels directly from carburizing temp.*
[l] *Carburize 1650-1700 F, quench fine grained steels directly from carburizing temp; water-quench from 1500-1550 F if not carburized.*

Prepared with the assistance of Bliss & Laughlin, Inc.

Brinell Hardness Numbers for Various Loads

The Brinell hardness number is influenced by the applied load, the diameter of the ball and its elastic properties. In the usual procedure, a ball having a diameter of 10 mm is used with a load of 3000 kg for steels and 500 kg for after materials. However, it is sometimes desirable to use intermediate loads. The Brinell hardness numbers for loads ranging from 500 to 3000 kg are given below.

BRINELL HARDNESS NUMBERS						
Dia. of Indentation	500 KGM Load	1000 KGM Load	1500 KGM Load	2000 KGM Load	2500 KGM Load	3000 KGM Load
2.00	158	316	473	632	788	945
2.05	150	300	450	600	750	899
2.10	143	286	428	572	714	856
2.15	136	272	409	544	681	817
2.20	130	260	390	520	650	780
2.25	124	248	373	496	621	745
2.30	119	238	356	476	593	712
2.35	114	228	341	456	568	682
2.40	109	218	327	436	545	653
2.45	104	208	314	416	522	627
2.50	100	200	301	400	500	601
2.55	96.3	193	289	385	482	578
2.60	92.6	185	278	370	462	555
2.65	89.0	178	267	356	445	534
2.70	85.7	171	257	343	429	514
2.75	82.6	165	248	330	413	495
2.80	79.6	159	239	318	398	477
2.85	76.8	154	231	307	384	461
2.90	74.1	148	222	296	371	444
2.95	71.5	143	215	286	358	429
3.00	69.1	138	208	276	346	415
3.05	66.8	134	201	267	334	401
3.10	64.6	129	194	258	324	388
3.15	62.5	125	188	250	313	375
3.20	60.5	121	182	242	303	363
3.25	58.6	117	176	234	293	352
3.30	56.8	114	171	227	284	341
3.35	55.1	110	166	220	276	331
3.40	53.4	107	161	214	267	321
3.45	51.8	104	156	207	259	311
3.50	50.3	101	151	201	252	302
3.55	48.9	97.8	147	196	244	293
3.60	47.5	95.0	143	190	238	285
3.65	46.1	92.2	139	184	231	277
3.70	44.9	89.8	135	180	225	269
3.75	43.6	87.2	131	174	218	262
3.80	42.4	84.8	128	170	212	255
3.85	41.3	82.6	124	165	207	248
3.90	40.2	80.4	121	161	201	241
3.95	39.1	78.2	118	156	196	235
4.00	38.1	76.2	115	152	191	229
4.05	37.1	74.2	112	148	186	223
4.10	36.2	72.4	109	145	181	217
4.15	35.3	70.6	106	141	177	212
4.20	34.4	68.8	104	138	172	207

BRINELL HARDNESS NUMBERS						
Dia. of Indentation	500 KGM Load	1000 KGM Load	1500 KGM Load	2000 KGM Load	2500 KGM Load	3000 KGM Load
4.25	33.6	67.2	101	134	167	201
4.30	32.8	65.6	98.5	131	164	197
4.35	32.0	64.0	96.0	128	160	192
4.40	31.2	62.4	93.5	125	156	187
4.45	30.5	61.0	91.5	122	153	183
4.50	29.8	59.6	89.5	119	149	179
4.55	29.1	58.2	87.0	116	145	174
4.60	28.4	56.8	85.0	114	142	170
4.65	27.8	55.6	83.5	111	139	167
4.70	27.1	54.2	81.5	108	136	163
4.75	26.5	53.0	79.5	106	133	159
4.80	25.9	51.8	78.0	104	130	156
4.85	25.4	50.8	76.0	102	127	152
4.90	24.8	49.6	74.5	99.2	124	149
4.95	24.3	48.6	73.0	97.2	122	146
5.00	23.8	47.6	71.5	95.2	119	143
5.05	23.3	46.6	70.0	93.2	117	140
5.10	22.8	45.6	68.5	91.2	114	137
5.15	22.3	44.6	67.0	89.2	112	134
5.20	21.8	43.6	65.5	87.2	109	131
5.25	21.4	42.8	64.0	85.6	107	128
5.30	20.9	41.8	63.0	83.6	105	126
5.35	20.5	41.0	61.5	82.0	103	123
5.40	20.1	40.2	60.5	80.4	101	121
5.45	19.7	39.4	59.0	78.8	98.5	118
5.50	19.3	38.6	58.0	77.2	96.5	116
5.55	18.9	37.8	57.0	75.6	95.0	114
5.60	18.6	37.2	55.5	74.4	92.5	111
5.65	18.2	36.4	54.5	72.8	90.8	109
5.70	17.8	35.6	53.5	71.2	89.2	107
5.75	17.5	35.0	52.5	70.0	87.5	105
5.80	17.2	34.4	51.5	68.8	85.8	103
5.85	16.8	33.6	50.5	67.2	84.2	101
5.90	16.5	33.0	49.6	66.0	82.5	99.2
5.95	16.2	32.4	48.7	64.8	81.2	97.3
6.00	15.9	31.8	47.8	63.6	79.5	95.5
6.05	15.6	31.2	46.9	62.4	78.0	93.7
6.10	15.3	30.6	46.0	61.2	76.7	92.0
6.15	15.1	30.2	45.2	60.4	75.3	90.3
6.20	14.8	29.6	44.4	59.2	73.8	88.7
6.25	14.5	29.0	43.6	58.0	72.6	87.1
6.30	14.2	28.4	42.8	56.8	71.3	85.5
6.35	14.0	28.0	42.0	56.0	70.0	84.0
6.40	13.7	27.4	41.3	54.8	68.8	82.5
6.45	13.5	27.0	40.5	54.0	67.5	81.0

Diameter of Ball 10 Millimeters.
Impression Diameters to 0.05 MM.

From INDENTATION HARDNESS TESTING by Vincent E. Lysaght; published by Reinhold Publishing Corp., 1949

Checking Wear of "S" Monel sleeves after one year of service in midget Jordan processing abrasive raw asbestos. Appearance of centrifugally-cast, 3½-inch O.D., "S" Monel sleeves indicate that they will outlast previous type of sleeves approximately 10 to 1.

"We're getting," says Republic Seitz Filter Corp., *"ten times as much service from these...sleeves."*

Let them show you what they discovered that helped them build extra wear resistance into these machine parts.

Sometimes abrasion is so severe that nothing you try seems to work.

That's how it was with the midget Jordan machine Republic uses to process asbestos for antibiotic filters. The sleeves that protect the shaft against the abrasive asbestos lasted only 15 months. Then, just over a year ago, they discovered Cast "S"® Monel . . . learned what it does to combat abrasion.

This picture, taken when the Jordan was stripped just recently, shows part of what happened as a result of their change to "S" Monel. Look first at the left end of the part. It rests on the centrifugally-cast "S" Monel intake sleeve. Can you see any wear?

How about the outlet sleeve . . . near the front of the picture? There is more pressure there, and even though the sleeve is "S" Monel, some scoring does show . . . but you can see, also, why Republic's engineers are enthusiastic . . . why they expect "ten times as much service" from their "S" Monel sleeves.

Formerly, wear was so severe they had to repack the glands once a week. But last year, with "S" Monel sleeves, they packed glands only six times. "In labor saving, alone," says a Republic official, "we have already gotten back the price of the 'S' Monel sleeves."

A quick return on an "S" Monel investment is no novelty. It happens often. It can happen to you . . . for Inco Cast "S" Monel gives you in full measure a superior combination of resistance to abrasion and corrosion . . . at high temperatures as well as low. It's heat-treatable. It's non-magnetic. It's cast to last. "Cast to Last," by the way, is the title of a new folder on Inco Nickel Alloy Castings that could be useful to you. We'll be glad to send it to you if you write:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N.Y.

INCO

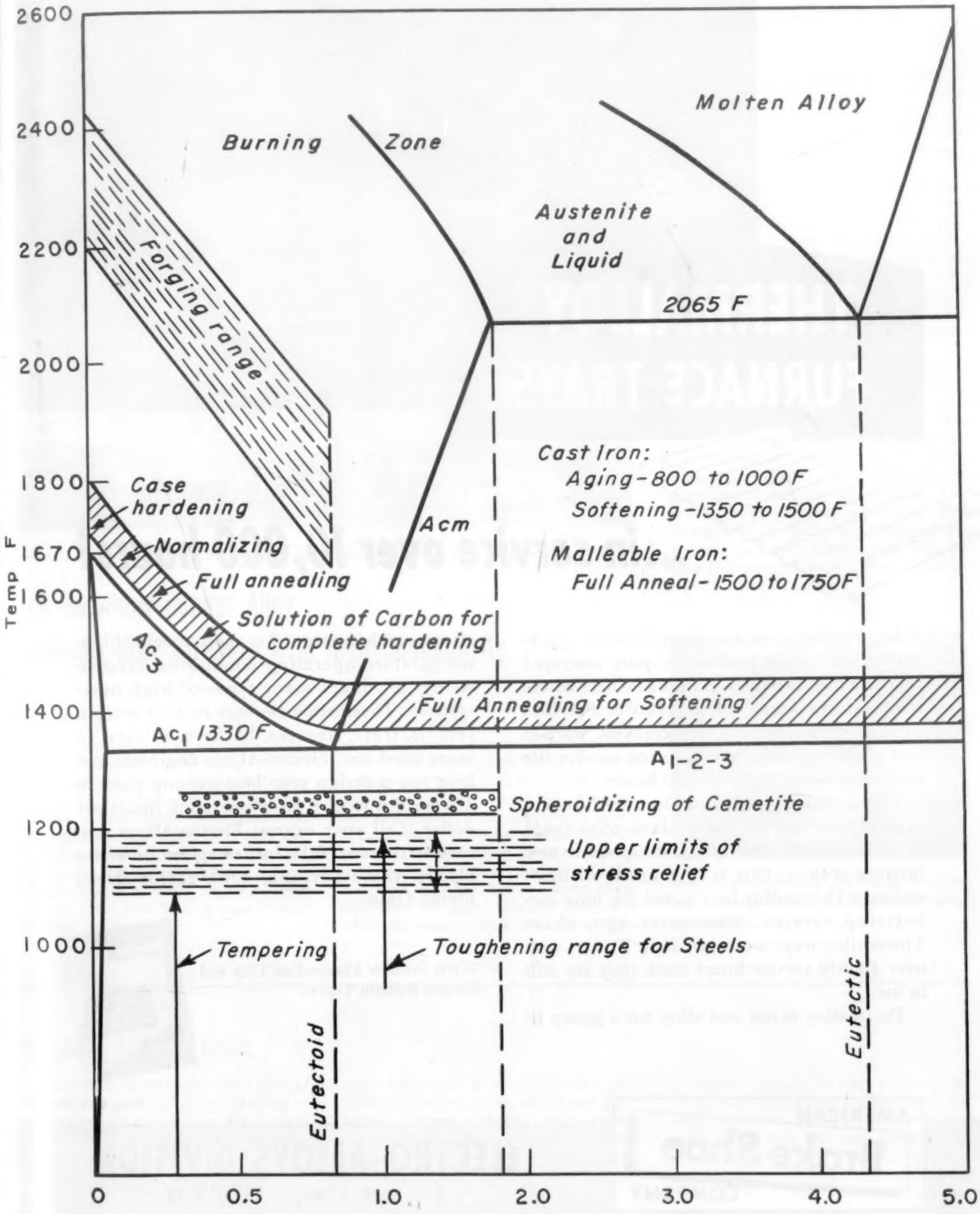
Inco Castings... *Sand, Centrifugal, Precision*

For more information, turn to Reader Service Card, Circle No. 490

Materials Engineering File Facts

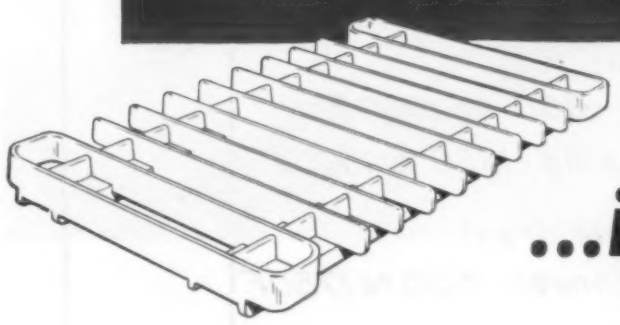
MATERIALS & METHODS
December • 1953
Number 267

Heat Treating Temperatures in Relation to the Iron-Carbon Diagram



From a paper by Edward J. Ocean at the A.G.A. Industrial Gas School, May 1953.

THERMALLOY* FURNACE TRAYS



...in service over 10,000 hours!

A large automotive parts manufacturer "pack-carburizes" drive pinions in pots conveyed two on a tray through a gas-fired furnace where temperatures range up to 1700°F. Previous designs of the furnace tray cracked, warped and scaled quickly, with average service life limited between 100 and 600 hours.

This manufacturer asked Electro-Alloys engineers how service life of these trays could be extended. Electro-Alloys designed a new furnace tray . . . cast it in a grade of heat-resistant Thermalloy best suited for long carburizing service. Two years ago, these Thermalloy trays were installed. Today, with over 10,000 service hours each, they are still in use.

Thermalloy is not one alloy but a group of alloys—each developed to meet specific high-temperature operating conditions. Electro-Alloys produces many types of high heat-resistant Thermalloy castings such as muffles, retorts, trays, fixtures, baskets, rollers. In many cases too, Electro-Alloys engineers can help you redesign your heat-treating parts in Thermalloy to give more operating hours per dollar. Call your nearest Electro-Alloys representative for full information or write Electro-Alloys Division, 4001 Taylor Street, Elyria, Ohio.

Write for new Thermalloy Tray and Fixture Bulletin T-226.

*Reg. U. S. Pat. Off.

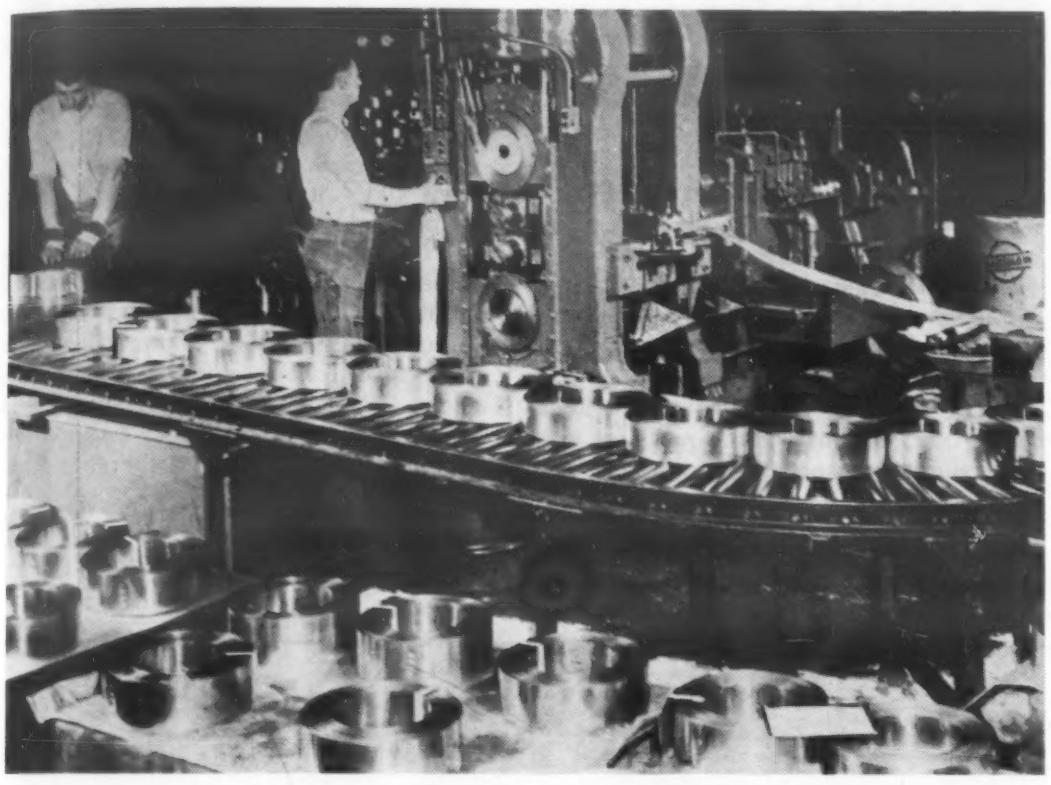
AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

For more information, turn to Reader Service Card, Circle No. 372

New Engineering Materials

. . . and Equipment for Their Processing



Beryldur, cold rolled in strip form, is now being produced on a commercial scale.

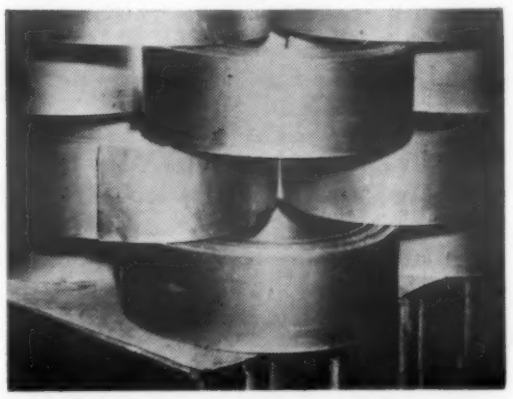
New Beryllium-Copper Alloy Combines High Strength With High Conductivity

A beryllium-copper alloy which unites high strength and hardness values with toughness and good electrical conductivity has now completed field testing and is being produced by the *Beryllium Corp.*, Reading, Pa. According to the company, Beryldur, a low content alloy containing only 1% beryllium which is midway between the amounts contained in the high strength and the high conductivity groups, fills the gap of property ranges existing between these two basic groups of the beryllium-copper family.

Standard Beryllium-Copper Alloys—The addition of beryllim to copper produces an age hardening alloy which can be rolled, drawn, stamped, cupped, spun, or otherwise worked in the soft or annealed condition. Then by a simple low temperature heat treatment the alloy can be given a high degree of hardness and tensile strength. The standard beryllium-copper alloys generally contain from 0.3 to 2.75% beryllium, with the higher content alloys containing the higher strength properties while the lower contain the higher conductivity. Their generally good fluidity enables them to reproduce intricate detail in sand, plaster, investment, and pressure castings. The corrosion resistance of the alloys also makes them valuable for outdoor and marine use.

General Applications—As one general application for the new alloy, the manufacturer views Beryldur as a potential rival of bronzes and brasses. Its excellent formability in the heat-treatable temper gives it one of its major advantages over other copper base alloys, and classed as a wrought alloy, it carries a lower price than others in this group with higher beryllium content. Applications of Beryldur are predicted for the electro-mechancial field, especially in the manufacture of springs and switches.

The alloy is produced in only two tempers: Heat-treatable and mill-hardened. The former is desirable where severe forming is needed or where peak physical properties of the alloy are essential. The mill-hardened Beryldur requires no heat treatment of finished parts. At present the company is producing the new alloy in strip form only; however, it will soon be available as wire or rod.

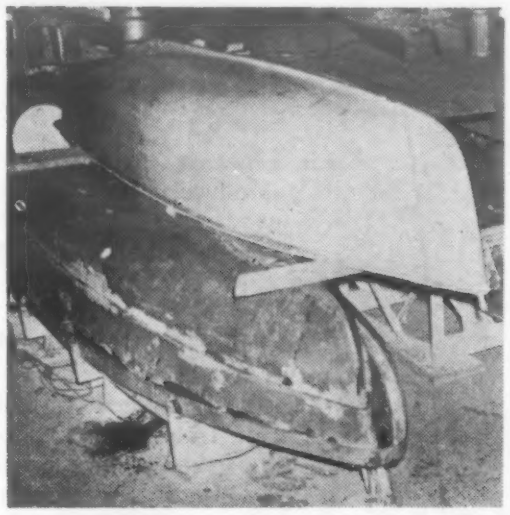


New beryllium-copper alloy strip is showing successful results in electro-mechanical applications.

New Clear Synthetic Finish

Exceptional clarity and high chemical resistance are said to be two features of a new synthetic baking type finish marketed by *Maas & Waldstein Co.*, 2130 McCarter Highway, Newark, N. J. Almost water-white in color, Durachem is specifically formulated to provide surface protection for silver, brass, nickel and other metals without changing their natural color or luster. It is said to have good resistance to salt spray and perspiration, and will not yellow after prolonged exposure to sunlight or high temperatures.

Typical applications for the finish are said to include builders' hardware, cosmetic cases, pen caps and similar metal parts. For decorative purposes, Durachem can also be supplied in a variety of colors.



Glass-reinforced polyester boat is freed more easily from its male and female mold by CD Mold Release B-2.

Two Mold Release Agents Will Aid Plastics Manufacturers

CD Mold Release B-2—Supplied as a paste, this material has been developed as a mold release for polyester, epoxy, and other plastics by the *Chemical Development Corp.*, Danvers, Mass. It is intended for use primarily on porous or semi-porous molds, including wood, polyester, plaster of paris, aluminum, and similar materials.

The release agent can be applied with a cloth or brush and can be rubbed down to a thin coating which is practically invisible. According to the company, it is insoluble in the resin and will not interfere with the proper cure of the plastic itself. Because it is quick drying, a fast molding cycle is possible. It has a high flash point, eliminating the need for red labels during shipment or storage, and due to its high heat resistance it will not run or sag under high temperature conditions.

H-561-B — Furane Plastics, Inc., Los Angeles, has developed a release agent particularly suited for use with epoxy resins, which are noted for their outstanding ability to bond metals, ceramics, and glass. According to the company, use of their H-561-B agent enables epoxy laminates and castings to be removed readily from metal and plaster molds.

The company says that for optimum results, plaster molds should first be hardened and sealed with a furane resin impregnating agent of theirs called Plaspreg before application of the release agent. The epoxy resin may be applied to the H-561-B coated mold within a few minutes after the mold has been treated.

New Silicone Pressure Sensitive Adhesive Material

Although most silicone products are so nonreactive that they make unusually effective release agents, two new compounds have been developed which are notable among adhesives for the tenacity with which they will stick to a wide variety of surfaces at varying temperatures.

Developed by *Dow Corning Corp.*, Midland, Mich., and known as Dow Corning XC-269 and XC-271, the materials are essentially solvent solutions of silicone materials, since, according to the company, they cannot technically be classified as glues or adhesives because they do not form a hard or brittle bond. Instead, they remain pliable and retain their adhesive strength even after long exposure to temperatures ranging from –65 to 480 F.

Adhesive Properties—At room temperature the adhesive properties of the two new materials compare favorably with those of organic adhesives; at higher or lower temperatures, however, they are superior in that their adhesive strength increases with the increase or decrease of temperature. In addition to their thermal stability, Dow Corning XC-269 and XC-271 possess excellent dielectric properties and good resistance to moisture, weathering and aging.

According to the company, the new compounds give excellent adhesion to such materials as metals, glass, paper fabrics, and plastics including polyethylene or polyester films. They adhere well to such "adhesive" materials as silicone rubber, silicone treated paper, fluorocarbon plastics, and various silicone laminates. They will also adhere well to most surfaces when applied under water. It is anticipated that the properties of these materials will enable manufacturers of pressure sensitive tapes to produce tapes for applications much too severe for other adhesive materials.

Method of Application—Dow Corning XC-269 and XC-271 are supplied at 40% silicone solids in xylene, at a viscosity suitable for knife coating. For spray or dip applications, they may be thinned with suitable solvents as shown in the table below. In any application of the materials, regardless of method of application, the solvent should be removed by air drying or heating 15 to 30 min at 158 to 212 F. When only adhesion is required, no further treatment is necessary. When the materials must exhibit pressure sensitive characteristics and must not give cohesive failure, the coated material must be given an additional short cure: For XC-269, a 5 min bake at 482 F; for XC-271, a 5 min bake at about 300 F.

The new silicone materials are not recommended for applications involving exposure to high concentrations of solvent vapors or oils. In addition they offer no particular advantage in the preparation of normal masking tapes, and can cause difficulty in painting over surfaces from which the tape is removed unless the surface is thoroughly cleaned with solvent first.

Physical Properties—	
Solids Content, %	40
Viscosity at 25 C, Centipoises	1000–3000
Flash Point, F	60–75
Weight Loss, %, 3 hr at 480 F	8
Specific Gravity	0.94
Shipping Weight, Lbs Per Gal	7.5
Shelf Life, Months: XC-269	6
XC-271	3
Solvent	Xylene
Thinners	Heptane, xylene, toluene or other aromatic hydrocarbon solvents.
Typical Properties of Cured Adhesive—	
Color	Water white
Density	1.04
Dielectric Strength, Volts Per Mil*	600
Dielectric Constant at 10^2 cycles	2.8
Power Factor at 10^2 cycles	0.005
Surface Resistivity, Megohms, after 4 days at 100% relative humidity	2000

* Measured on 3 mil films, cured on aluminum panels and tested with ¼ inch electrodes.

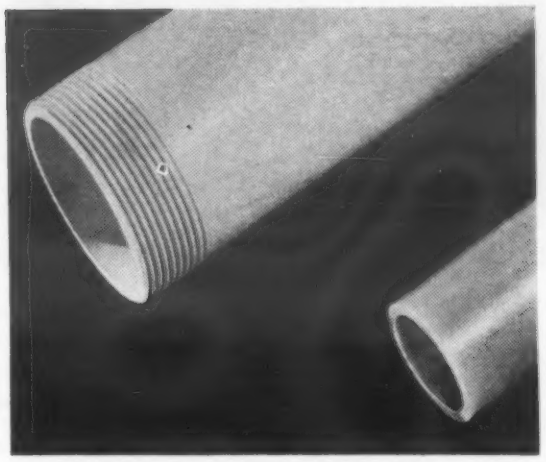
Extruded Polyvinyl Chloride Pipe Has Good Chemical Resistance

The *Carlon Products Corp.*, 10225 Meech Ave., Cleveland, has started the production of rigid, unplasticized polyvinyl chloride pipe in a range of sizes, capable of withstanding maximum working pressures ranging from 195 to 500 psi.

Extruded Carlon "V" pipe utilizes the properties of the polyvinyl chloride in that it has exceptional resistance to a wide range of organic and inorganic chemicals, and is practically unaffected by all mineral acids, bases and salts, chlorine, oil, grease, gasoline, alcohol and carbon tetrachloride.

Weighing about 1/5 as much as steel and about 1/2 as much as aluminum pipe, the relatively high structural strength and dimensional stability of the pipe, together with its toughness make it suitable for numerous applications where chemical, atmospheric and electrolytic conditions create maximum maintenance costs in the use of metal pipe. High dielectric strength, low water absorption and nonflammable characteristics make it useful as an electrical insulator and for conduits.

The Carlon "V" pipe is available to industry in two types: 1) A medium impact pipe with high chemical resistance, or 2) a high impact type pipe with a sacrifice in chemical resistance.



Plastic pipe weighs about ½ as much as aluminum.

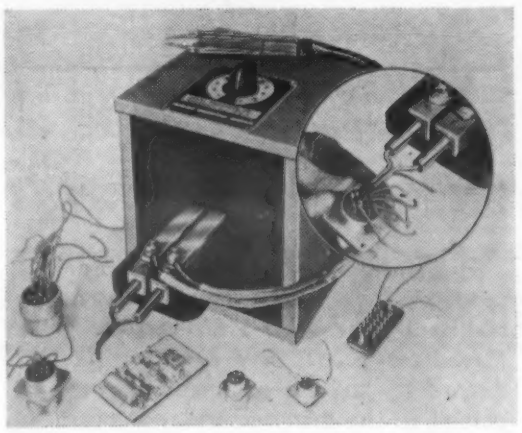
Tweezers Add Versatility to Soldering Machine

The 250 w AN Connector Soldering Machine produced by *Joyal Products, Inc.*, 115 Edison Pl., Newark, N. J., is now being made with soldering tweezers as well as the regular soldering electrodes, greatly increasing the machine's versatility for the soldering of small parts on a production basis.

The tweezers are air-cooled, permitting continuous use; they have glass fiber insulation, and the replaceable electrodes can be shaped to fit any type of operation. The average life of the electrodes under continuing use is estimated at about three months.

The fixed electrodes can solder more than 30 terminals on AN Connectors. They can also be used on terminal boards, on printed circuits with high temperature solder that can not be handled with a soldering iron, and for solder crimped lugs, to government specifications.

To operate the fixed electrodes, the operator sets the heat and the solder, brings the work to the electrodes and presses the foot switch. The electrodes can reach into tiny areas where regular soldering iron cannot penetrate.



Air-cooled tweezers simplify production soldering of small parts.

Cobalt Alloy Sheet Cold-Rolled to 0.0005 Inch Thickness

Haynes Alloy No. 25 (L605) sheet is now being cold rolled to a thickness of 0.0005 in. by *Metals & Controls Corp., General Plate Div.*, Attleboro. Mass.

The cobalt base alloy has high strength and hardness combined with excellent corrosion resistance at temperatures up to 1500 to 2000 F. The cold working of the alloy results in hardnesses as high as 55 Rockwell C, while the accompanying ultimate strength is about 322,000 psi and the elongation is about 2%. This results from 50% cold reduction followed by an aging heat treatment.

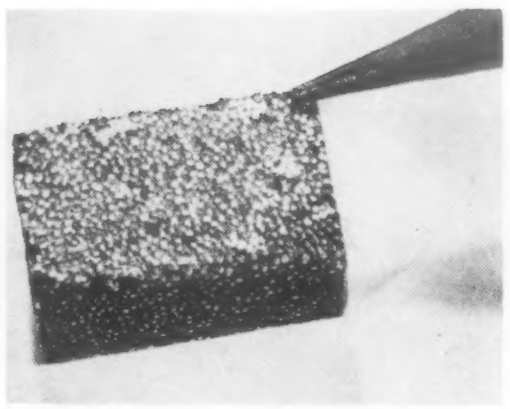
At 20% reduction and no subsequent aging, the alloy has an ultimate strength of 192,000 psi, yield of 163,000 psi, an elongation of 27%, and a hardness of 44 Rockwell C.

According to the company, various applications for the alloy include stem pads on valves handling super-heated steam, deflectors to prevent hot spots in aircraft jet engines, thin spring blades for high-temperature switching devices, diaphragms, rupture discs, and industrial knives.

The Haynes Stellite Multimet (N155), Hastelloy "B", and Hastelloy "C" Alloys are available in a cold-worked condition in thicknesses from 0.125 to 0.0005 in.

New Engineering Materials continued

Metals, Resins, and Pigments Join in Self-Lubricated Bearing Material



A new self-lubricating metal which is said to have exceptional bearing strength has been developed by *Booker-Copper, Inc.,* 8387 Melrose Pl., Los Angeles.

The new material is a combination of metal particles, both ferrous and non-ferrous, a thermosetting resin and lubricative pigments all locked together so that metal is fused to metal, then doubly locked into a solid mass with a resin-pigment to permit permanent lubrication and to gain high bearing strength. The ratio of lubricative pigment to metal can be controlled to meet the requirements of specific bearing pressures.

The ratio of lubricative pigments to metal can be controlled to meet specific bearing requirements in this self-lubricating material.

The metal may be used dry or in conjunction with oil, and the company states that the lubricating qualities afford permanent lubrication for the life of the part.

Two New Resin Finishes Protect Ferrous Metals

The *Parker Rust Proof Co.,* Milwaukee Ave., Detroit, has marketed two new pigmented phenolic resin finishes for use over their Parco Compound. According to the company, their research laboratories have proven the two finishes on iron and steel pieces of many sizes and shapes.

Parcolac 101 Black is said to produce an intense black color, while Parcolac 102 Aluminum creates an even, light gray finish which looks like aluminum plating. The manufacturer states that both products have high corrosion resistance, finished pieces having withstood 100 hr salt spray exposure.

Free Machining Tool Steels

High alloy tool steels, including high speed steels which contain free machining additives are now available from the *Vanadium-Alloys Steel Co.,* Latrobe, Pa. According to the company, experience gained in the manufacture and control of their Speed-Cut tool steel has enabled them to market for test purposes, high speed steels with free machining characteristics.

While the effect of free machining additives on the tensile strength, impact strength, etc., of steels is well known, the effect on edge strength of cutting tools has yet to be determined. Where edge strength is most important to cutting efficiency, extensive testing will be necessary to determine where such steels can be best applied. the company says.

They believe that their FM series of high speed steels will probably be first employed for use on tools which cannot be ground and where a smooth finish from machining is essential. Typical examples would be unground form cutters and hobs.

Since higher machining speeds can be used, savings in production costs can be expected on any tools where such steels can be made applicable.

Non-Leafing Aluminum Pigments for Metallic-Appearing Paints

Two new types of non-leafing aluminum pastes have been developed for use in protective and decorative coatings. Developed by *Metals Disintegrating Co., Inc.,* Elizabeth B, N. J., MD 584 and MD 784 are non-leafing in that though they carry a grease film, it is of such a nature that the flake will neither leaf nor flow when it is formulated in a paint or other finish. This property makes possible the uniform dispersion of the pigment throughout the paint film and yields the characteristic metallic appearance, the company states. In finishes of this type, the color is further accentuated by a high contrast or "flop" in the appearance of the film when viewed from various directions. The pigments provide increased durability of finish due to the presence of metal particles which reflect deteriorating light rays. The pigments are said to disperse easily and quickly in finish formulations due to the non-leafing characteristic and uniform particle size distribution.

The MD 584 Non-Leafing Aluminum Paste, Standard Lining Grade, is recommended for improving the appearance and workability of "metallic" finishes for automotive or industrial uses while the MD 784, Fine Lining Grade, has been developed specifically for hammer finishes and metallic enamels.

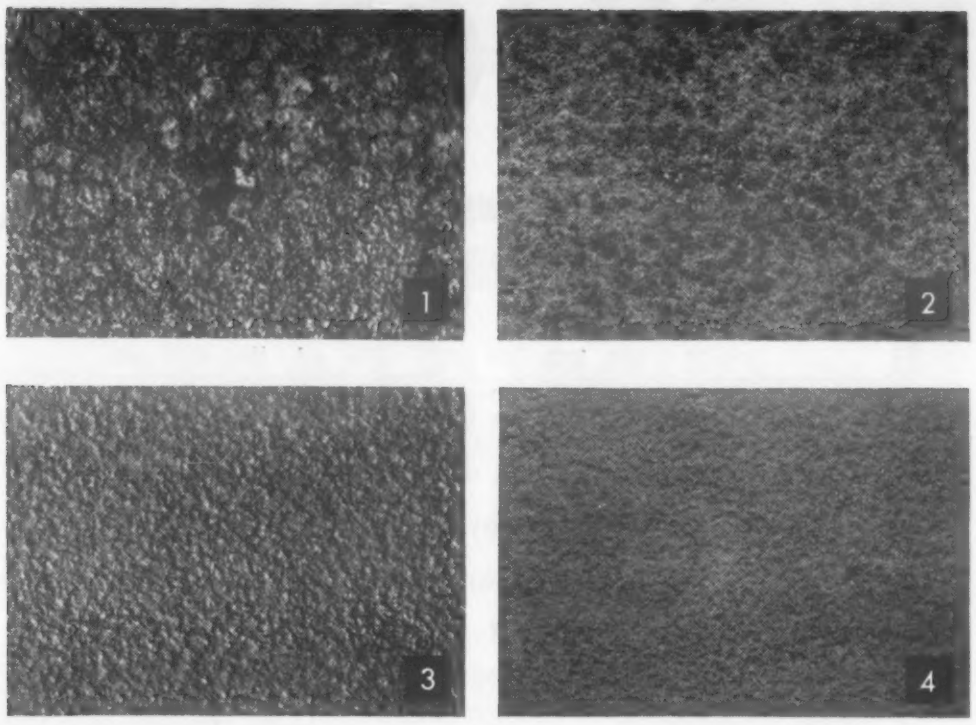
(Continued on page 154)

Specify

N-A-X
HIGH-TENSILE STEEL

for

Longer Life through Corrosion Resistance



Photographs show effects of atmospheric corrosion after six years' exposure of unprotected surfaces.

1. Low carbon sheet steel showing friable heavy rust.
2. Low carbon sheet steel with rust removed showing heavy pitting.
3. N-A-X HIGH-TENSILE sheet steel showing tightly adhering rust.
4. N-A-X HIGH-TENSILE sheet steel with rust removed showing absence of excessive pitting.

Low carbon sheet steel lost four times more weight than N-A-X HIGH-TENSILE in six-year test. With increased time this ratio becomes greater.

N-A-X HIGH-TENSILE, having 50% greater strength than mild carbon steel, permits the use of thinner sections—resulting in lighter weight of products. It is a low-alloy steel—possessing much greater resistance to corrosion than mild carbon steel, with either painted or unpainted surfaces. Combined with this characteristic, it has high fatigue and toughness values at normal and sub-zero temperatures and the abrasion resistance of a medium high carbon steel—resulting in longer life of products.

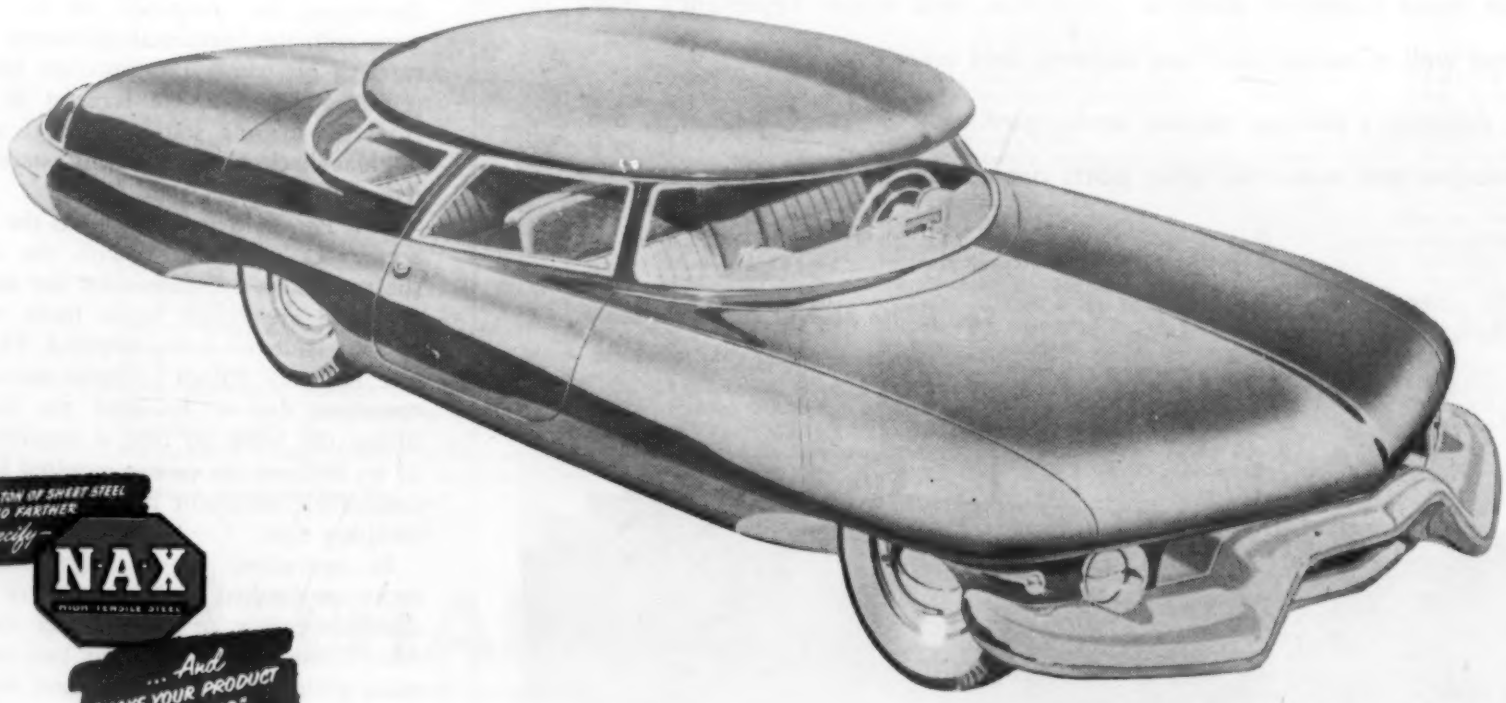
N-A-X HIGH-TENSILE, with its higher physical properties, can be readily formed into the most difficult stamped shapes, and its response to welding, by any method, is excellent. Due to its inherently fine grain and higher hardness, it can be ground and polished to a high degree of lustre at lower cost than can mild carbon steel.

Your product can be made lighter in weight . . . to last longer . . . and in some cases be manufactured more economically, when made of N-A-X HIGH-TENSILE steel.

GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division — Ecorse, Detroit 29, Michigan

NATIONAL STEEL CORPORATION

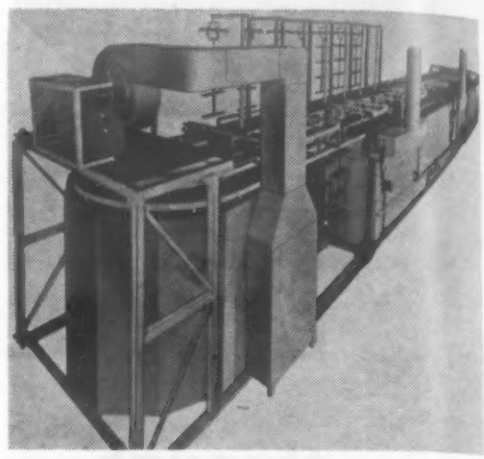


MAKE A TON OF SHEET STEEL GO FARTHER
Specify—
NAX
HIGH TENSILE STEEL
... And "MAKE YOUR PRODUCT LAST LONGER"

KEEP YOUR SCRAP MOVING TO YOUR DEALER

For more information, turn to Reader Service Card, Circle No. 469

New Engineering Materials



Automatic Plating Machine Operates on Novel Principle

The fully automatic electroplating machine designed by *Wagner Bros. Equipment Co., Inc.,* Detroit, incorporates a new approach to plating transfer machines in that no elevating superstructure, no transfer cams, no chains or sprockets and no hydraulic fittings are positioned above the tanks.

The transfer and conveying principle around which the machine is built has but two reciprocating movements, longitudinal and vertical. All working parts are mounted on a central carriage which moves on a single track and is actuated by an hydraulic cylinder. Basically this supplies the horizontal motion to the work through the cleaning and plating tanks and drying oven which surround the carriage.

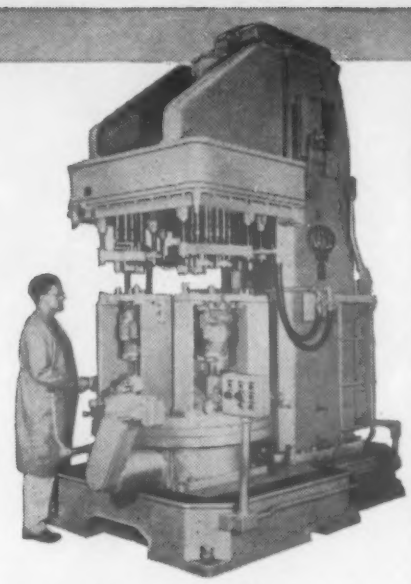
A shaft running the length of the carriage, near its top, is fitted with gears which are meshed to racks on the work lifting arms. This assembly provides the vertical motion which lifts and lowers the work out of and into the tanks. Synchronizing the movement of the lifting arms with the horizontal movement of the carriage on which the arms are mounted provides the complete transfer of work from the loading station, through all operations back to the loading station for removal.

Low Power Requirement—As the lifting arm racks are meshed with the central shaft gears on opposite sides, the arms on one side are raised while those on the opposite side are being lowered. This feature not only allows a simple mechanical operation, but it balances the load of lifting the work so that it requires only 25 to 50% of the power required for any comparable automatic plating machine, the company says.

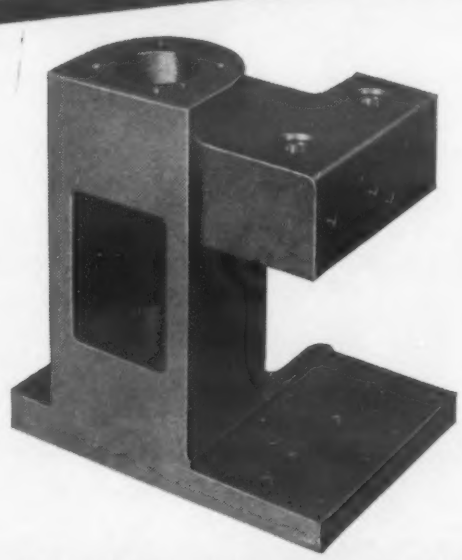
In operation, the plating baskets or racks are hooked to work carriers which are independent of the transfer mechanism. These carriers rest on two cathode rails, giving double contact and assuring constant current supply to the work.

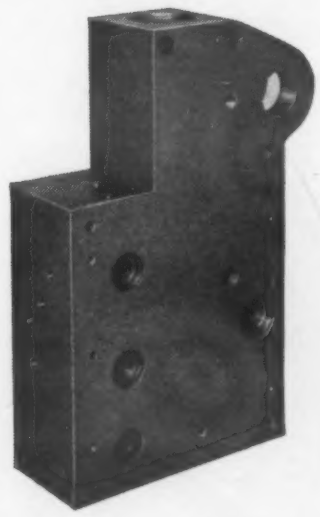
(Continued on page 157)

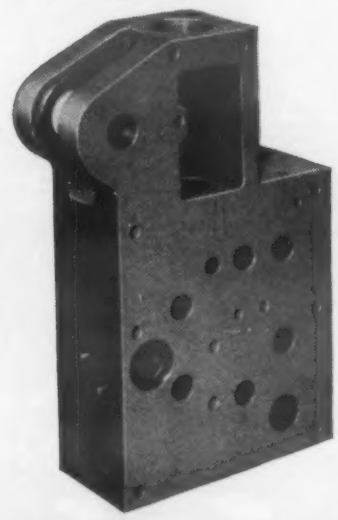
When HIGH Pressures Create Problems Solve Them With MEEHANITE® CASTINGS



NATCO—C4A Multiple Drilling, Boring, Facing and Tapping Machine







Views of Control Panel Valve Bodies, Pressures Up to 1500 p.s.i.

PRESSURE TIGHTNESS, of course, requires DENSITY,—and density can be achieved only by close control of each and every step in casting manufacture;—from charging floor to shipping platform. Meehanite foundries have long been noted for the QUALITY of their product, a result of their use of Meehanite process controls;—controls which result in uniform—dense—better property castings.

PROOF of this is found in the important applications of Meehanite castings made by the National Automatic Tool Co., Inc., Richmond, Indiana, in hydraulic control valve bodies. These units are the heart of the operating mechanism of their line of NATCO Drilling, Boring, Facing and Tapping Machines. The castings and the machine tool are illustrated.

Write for Bulletin #10—Meehanite, The Metal For Pressure Castings. It may give you an idea that will lead to the solution of one of your problems.

Only a **MEEHANITE** *Foundry Can Make* **MEEHANITE** *Castings*

American Brake Shoe Co.	Mahwah, New Jersey
The American Laundry Machinery Co.	Rochester, New York
Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington and Dover, New Jersey
E. W. Bliss Co.	Hastings, Mich. and Toledo, O.
Builders Iron Foundry	Providence, Rhode Island
Compton Foundry	Compton, Calif.
Continental Gin Co.	Birmingham, Alabama
Crawford & Doherty Foundry Co.	Portland, Oregon
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
M. H. Detrick Co.	Newark, N. J. and Peoria, Ill.
Empire Pattern & Foundry Co.	Tulsa, Oklahoma
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Hardinge Company, Inc.	New York, New York
Hardinge Manufacturing Co.	York, Pennsylvania
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Koehring Co.	Milwaukee, Wisconsin
Lincoln Foundry Corp.	Los Angeles, California
London Concrete Machinery Co., Ltd. (Hartley Fdry.)	Brantford, Ontario
E. Long Ltd.	Orillia, Ontario
Otis Elevator Co., Ltd.	Hamilton, Ontario
Palmyra Foundry Co., Inc.	Palmyra, New Jersey
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
The Prescott Co.	Menominee, Mich.
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Sonith Industries, Inc.	Indianapolis, Ind.
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
Valley Iron Works, Inc.	St. Paul, Minnesota
Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey

"This advertisement sponsored by foundries listed above."

MEEHANITE®

714 North Avenue

NEW ROCHELLE, N. Y.

MEEHANITE MEANS BETTER CASTINGS

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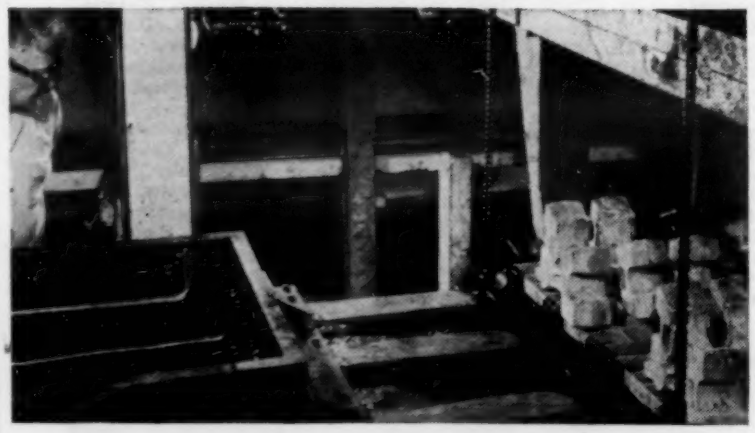
Picture shows how oil that forms sludge can clog cooler. Sun Quenching Oil's natural detergency helps prevent such sludge formation.

Oil Coolers Don't Clog with

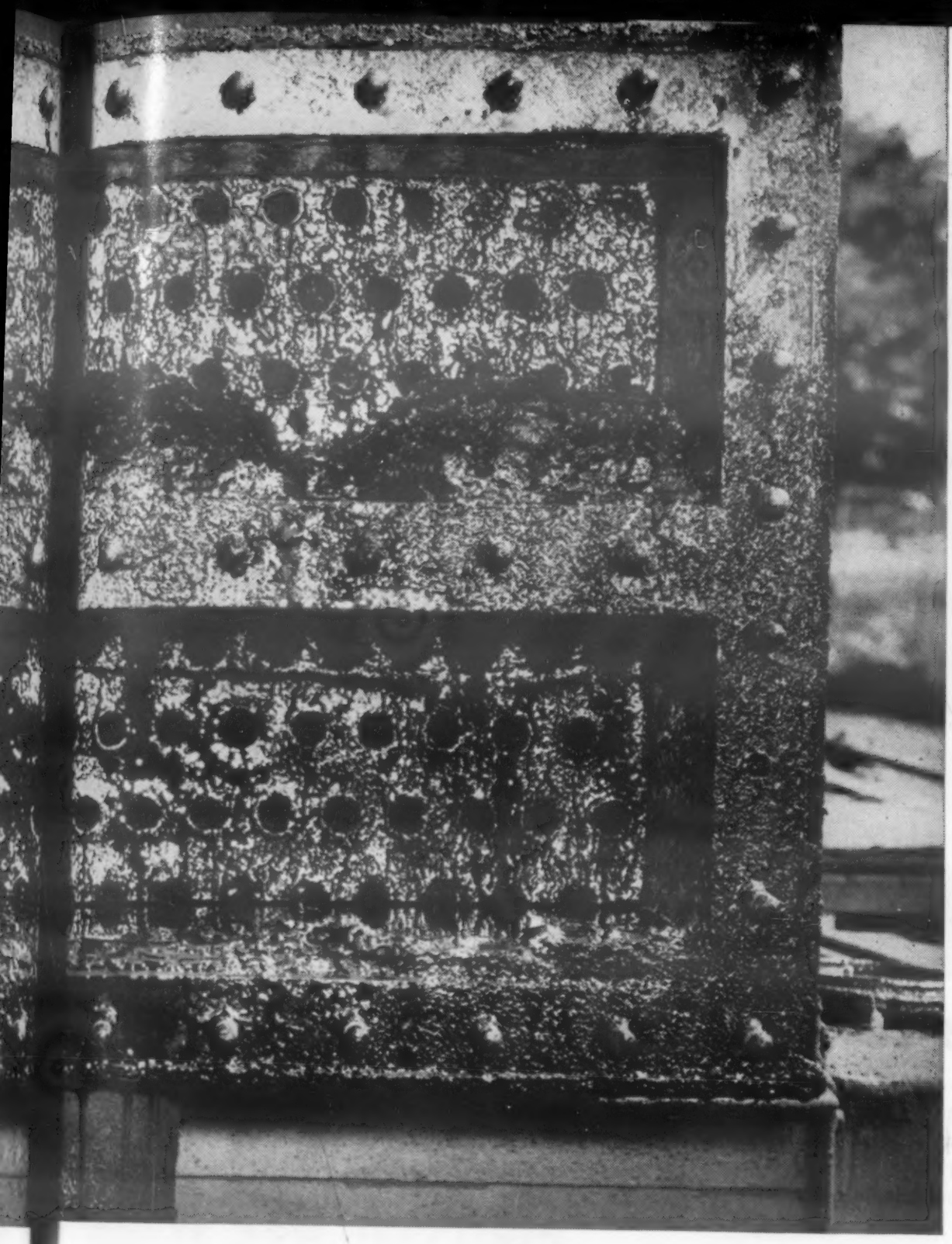


A New England firm uses five 2400-3000 gallon systems to quench all types and sizes of aircraft and automotive forgings. Since Sun oil was adopted 7 years ago, not one system has required cleaning except for normal removal of mill scale.

Sun Quenching Oils keep oil coolers clean. Teardowns are fewer and maintenance costs less. This is because Sun oils have a natural detergent action that prevents the formation of sludge and aids in removing any deposits that exist.

Can Handle 95% of All Quenching Jobs

Tests show that Sun Quenching Oils give better all-around results. For one thing, they assure hardnesses far above the commonly accepted minimum requirements. In any system that provides normal agitation, they can handle 95 per cent of all quenching jobs.



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When the machine is set in motion, lifting arms lower at the loading station, the carriage moves to the left and pads on the lifting arms engage the work carriers. The arms raise, lifting the work, the carriage moves to the right a preset distance and the arms lower the work into the cleaning tank. While work is being moved on one side of the machine the arms on the other side are returning to their pickup position.

Simultaneously work has been lifted out of the cleaning tanks, pickling tank, and plating tank all along one side of the machine and redeposited in the next succeeding tank. Where the work is to remain for a period as in cleaning or plating tanks, the carrier remains on the cathode rails and is moved along by pushers, actuated by the reciprocating central carriage. Where no current is required, as for cleaning tanks, the rails are not electrified.

Basic power is supplied by a single electric motor and hydraulic pump, which with the control panel may be located at any convenient point. Maintenance of the machine is simplified by the fact that all working parts are located between and higher than the tanks. Two sets of controls afford flexibility for adjustment of timing of all, or part of the complete operation.

Chill Unit for Production Heat Treating

A low temperature chilling machine designed for production chilling of ball and roller bearings for stabilization has been marketed by *Sub-Zero Products Co.*, Cincinnati, Ohio. The unit is factory adjusted to operate at −120 F and can be operated at −150 F. It has a capacity of 22 cu ft and a thermal capacity of 4000 Btu per hr.

Intended for incorporation into heat treat production lines, the unit receives the bearing parts in a basket from an oil quench by means of a mechanical lift. The unit is filled with a convection fluid, Freon 11, to gain rapid heat transfer and cooling. A twin-blade agitator is mounted in the corner of the chamber to drive the Freon 11 down a draft tube, through a manifold and up through the perforated bottom of the basket of parts. This forced convection cooling is said to permit the cooling of 170 lb of steel an hour from 80 down to −120 F.

The chilling chamber, which is 38 by 32 by 36 in. deep, is built of 7 gage steel for strength and safety. Outside di-

New Engineering Materials

mensions of the unit are 84 by 61 by 50 in. high.

According to the manufacturers, the design of the unit prevents condensation and assures a dry exterior cabinet in any climate. The lid is counter-balanced to stay open in any position, leaving both hands of the operator free.

Two Glues for Plywood and Furniture Industries

Two new liquid urea resin adhesives with high solid contents have been developed for the plywood and furniture industries by *Monsanto Chemical Co.'s, Plastic Div.,* Springfield, Mass.

According to the company the high rate of reactivity, particularly in hot press operations, is the main advantage in the use of Lauxite UF-101A and Lauxite UF-112 which contain 60 and 65% solids respectively. Due to this high rate of reactivity, production increases of approximately 25% have been obtained with the use of the glues, the company says.

Lauxite ureas are especially recommended for use with Lauxite MF-300 melamine resin adhesive in urea-melamine combinations. To such mixtures they are said to impart improved durability as measured by boil resistance.

Amplimeter Shows Roughness in RMS or Arithmetical Average

Amplimeter, an intrument designed for use with all Profilometer equipment is now available and will show either the rms or arithmetical average roughness height, in microinches, of a metal sample. Either scale may be selected by adjusting a switch on the panel.

(Continued on page 160)

You're missing something if you overlook

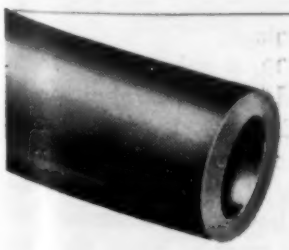
CRUCIBLE HOLLOW TOOL STEEL

If you make tool steel parts with machined-out centers, don't overlook the many benefits of using Crucible Hollow Tool Steel.

It eliminates drilling, boring, cutting-off and rough facing operations. Naturally, this cuts overall production time, steps up machine capacity and reduces scrap losses. Many manufacturers have been able to cut material costs alone by as much as 20% when they use Crucible Hollow Tool Steel instead of regular bar stock.

Crucible Hollow Tool Steel is available in three famous grades: KETOS oil hardening, AIRDI 150 air hardening, and SANDERSON water hardening tool steels. We supply it with machine finished inside and outside diameters and faces — cut to your specific length requirements. And no steel producer can assure you of more uniform quality. For we have complete control over every phase of manufacture and distribution.

For more information, call the Crucible warehouse nearest you . . . or write for new brochure describing Crucible Hollow Tool Steel. Address Crucible Steel Company of America, Dept. MM, Oliver Bldg., Pittsburgh 22, Pa.



CRUCIBLE first name in special purpose steels

53 years of Fine steelmaking

HOLLOW TOOL STEEL

CRUCIBLE STEEL COMPANY OF AMERICA • TOOL STEEL SALES • SYRACUSE, N. Y.

For more information, turn to Reader Service Card, Circle No. 301

New Engineering Materials

Designed and manufactured by the *Micrometrical Mfg. Co.*, Ann Arbor, Mich., the Type QA Amplimeter is designed for use in production departments, is portable, and is said to conform to the proposed new ASA Standard B46.1 as regards all technical details. It is not sensitive to mechanical shock or vibration, has a 30 sec warm-up, and the company states that it is not affected by normal temperature changes or line voltage fluctuations from 90 to 130 v. It has no sensitivity adjustment, and no calibration is required of the operator. The accuracy of the instrument can be checked by tracing a rated roughness specimen furnished as standard equipment.

The unit includes a high-stability industrial type electronic amplifier enclosed in a dust-tight metal case. A panel at the front carries a direct-reading microinch meter with illuminated dial, a switch for selecting rms or arithmetical readings, and a range selector switch. The latter provides a choice of six measurement ranges —0 to 3, 10, 30, 100, 300, or 1000 microinches—permitting surfaces of less than one microinch to be measured as well as surfaces of about 1000 microinches.

A storage compartment in the top holds the Tracer cable and other equipment, and the hinged compartment cover has a recessed latch and carrying handle. Overall dimensions are 8 in. wide, 10 in. high, and 15 in. front-to-back. The net weight is about 24 lb.

Petroleum Compound Protects Metals from Corrosion

A new leaded petroleum compound developed for the protection of metal surfaces against corrosion has been marketed by the *Brooks Oil Co.*, 934 Ridge Ave., Pittsburgh. According to the manufacturer, Barcote No. 600 is recommended for four basic types of applications: Protection of structural steel and sheet metal; protection of rails, and rail joints; lubrication of wire rope; and protection of metal parts in storage.

Barcote No. 600, a solvent, cut back, leaded compound, can be applied by either brush or air spray. It provides coverage with a thin film which sets to a semi-hard coating of pure lubricant and which is said to have good adhesion and penetration of all metals. Since the film is semi-hard and rubber-like it is said to expand and contract without flaking, cracking, pulling away, blistering or failing. In the 4g test on the Timken Testing Machine, the company claims the film carries 43 lb lever arm load for 30 min.

The material will flow at 0 F, does not

Economy in pilot or development small lots as well as in program production can be achieved by consultation with Lenape for recommendations on seamless or weldment construction requiring:

- Circular of symmetrical flanged or flued members of ¼" to 4" rolled plate stock.
- Upset flanged or plain forged and pierced rings.
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Expanded facilities have extended our range of capacity. Mail sketch or print direct, or consult nearest representative.

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DEPT. 112 WEST CHESTER, PA.
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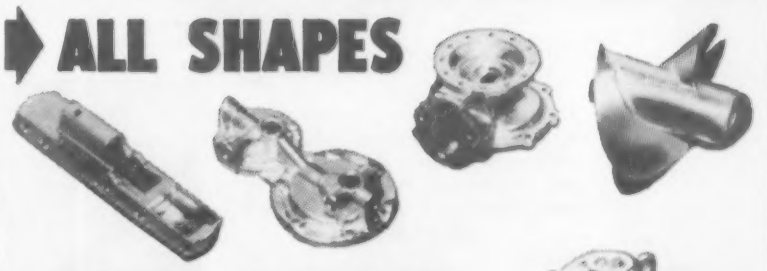
DOLLIN Zinc & Aluminum DIE-CASTINGS

ALL SHAPES

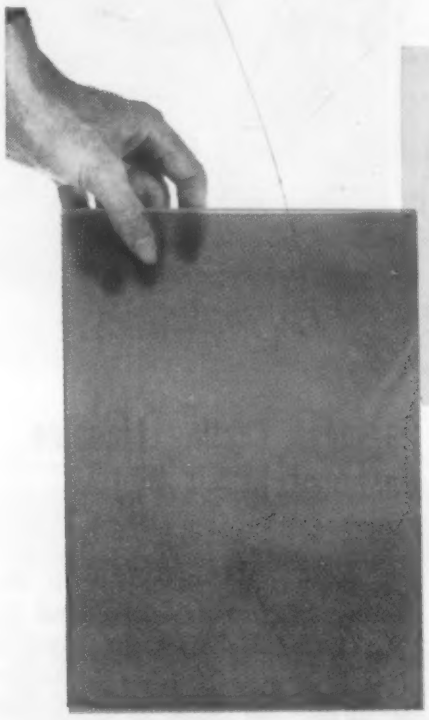


ALL SIZES

ALL LOW COST

Investigate! Leading manufacturers specify Dollin Die-Castings for highest quality at lowest cost. Send prints or samples for quotation—engineering advice at no obligation. Literature on request.

DOLLIN CORPORATION
610 So. 21st St., Irvington 11, N. J.



Formica announces another new ENGINEERED GRADE FF33

No other single grade of laminated plastics has ever offered a more useful combination of properties:

- Lowest moisture absorption
- Great arc resistance
- Excellent dimensional stability
- High dielectric strength
- Low loss electrical properties
- Dependable continuous service at temperatures as high as 350°F
- Good chemical resisting properties

How can you use it? Send for your sample today!

The new Formica FF-33 has more useful electrical and mechanical properties than have ever before been combined in a single grade. Made of a fine weave fibreglass cloth and impregnated with a special new resin, FF-33 promises to be one of the most useful and popular grades ever developed by Formica. It has already been tested and approved by several leading U.S. manufacturers.

FF-33 may be the perfect solution to one of your problems. You can see and test it without obligation. Why not send for your sample today? Use convenient coupon below.

THE FORMICA CO.
4678 Spring Grove Avenue
Cincinnati 32, Ohio

Gentlemen: Send me promptly and without obligation 6" x 6" x 1/16" sample of the new Formica FF-33.

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ADDRESS_____

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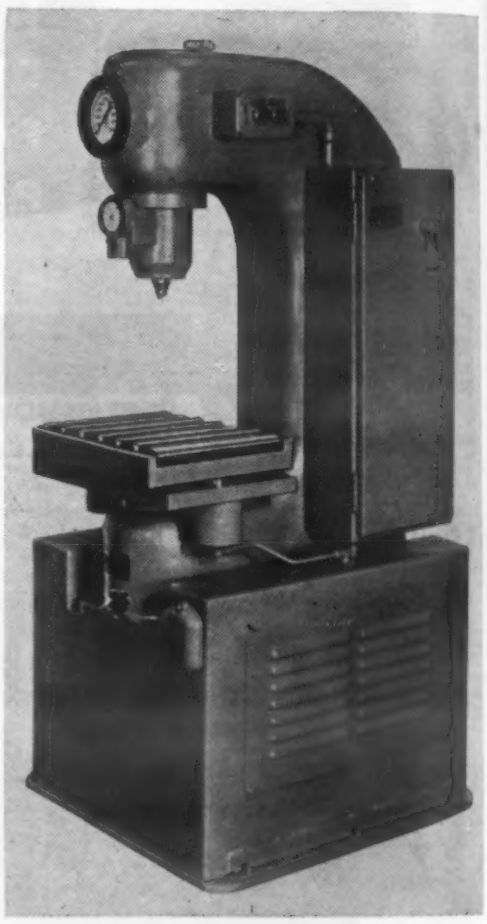
emulsify with water and has penetrating action sufficient to carry it behind scale and through rust. It does not evaporate in storage, never dries hard and has a strong affinity for metals. It is said to resist the action of salt water, is soluble in petroleum solvents, does not clog spray equipment, and may be filtered through a 0.005 in. mesh unit.



Hardness Testing Machine Designed to Fit Into Conveyor System

A production model Brinell Hardness Testing Machine, manufactured by *Steel City Testing Machines, Inc.*, 8817 Lyndon Ave., Detroit, features a roller conveyor arranged in conjunction with the anvil of the tester. The anvil consists of a series of hardened steel bars, between which the rollers are interspersed. The rollers then raise and lower automatically during the testing cycle.

The machine Model KDR-10X, is a direct reading type of tester, motor driven and hydraulically operated. The parts are fed to the machine on a delivery conveyor. The operator rolls the part into position beneath the ball penetrator and depresses the knee switch. The roller conveyor automatically lowers, allowing the part to come to rest on the anvil bars. Then the ball penetrator automatically lowers, ap-

New Engineering Materials

plying the load and making the Brinell impression. An electric timer holds the load for a selected interval after which the penetrator raises, the roller conveyor raises, and the operator rolls the part off the machine onto another matching conveyor which carries it on to the next operation.

The direct reading dial makes it unnecessary for the operator to measure the diameter of the impression during testing. The dial is a comparator indicator which indicates the depth of the impression. Two hands on the dial can be set at the soft and hard limits allowable, and a glance at the indicating hand will show whether the part falls within these limits.

Multiple Angle Metal Hardness Tester

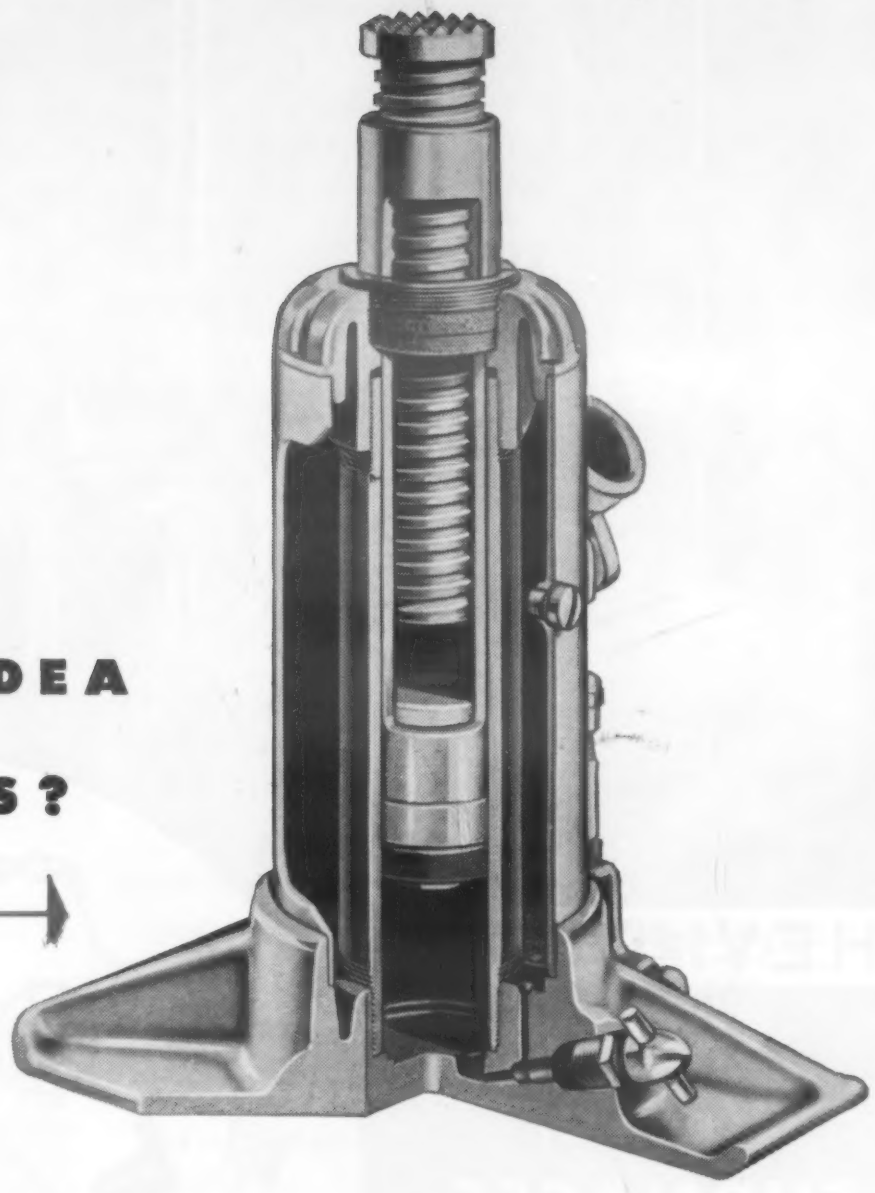
A new multiple-angle, semi-portable metal hardness tester, which does not use clamps, has been developed for use on areas and surfaces inaccessible when clamps are employed. It also has the advantage of being adaptable as a conventional bench-type hardness tester.

Marketed by *C. Tennant, Sons & Co.*, 100 Park Ave., New York, the Penetrascope Multiple Angle Metal Hardness Tester consists of a modified portable Penetrascope, movably mounted on a slotted stand, the base of which contains electro-magnets which hold the unit firmly to a surface table, lay-out table, or other ferrous base.

The unit is capable of both conventional and multiple angle testing by 1) Adjusting the height of the mounted Penetrascope on the slotted stand, 2) Setting the mounted Penetrascope at the required vertical angle, or 3) Setting the base of the slotted stand to the required horizontal angle.

The instrument employs the 136 deg

CAN YOU LIFT AN IDEA FROM THIS?



● Inside that jack, the lifting cylinder must withstand concentrated pressures. Outside, the housing gets rough service.

What material would you use to do the job?

Manufacturers of hydraulic jacks use Republic ELECTRUNITE Welded Steel Tubing . . . whether they make jacks that raise cars . . . or houses. They find ELECTRUNITE has the high strength that stands up under this kind of pressure. Takes rough service in stride.

Republic ELECTRUNITE is often cheaper. It's uniformly concentric, and that eliminates costly machining for close-tolerance parts. Makes a strong jack handle, too.

There may be a place for Republic ELECTRUNITE Welded Steel Tubing in something you plan to produce. Or in your present products. We'll be glad to help put ELECTRUNITE Tubing to work for you . . . in the right places. Just write:

STEEL AND TUBES DIVISION
REPUBLIC STEEL CORPORATION
231 EAST 131st STREET • CLEVELAND 8, OHIO

Republic
REPUBLIC STEEL
ELECTRUNITE TUBING

MADE BY THE PRODUCERS OF ELECTRUNITE...THE ORIGINAL ELECTRIC WELDED BOILER TUBE

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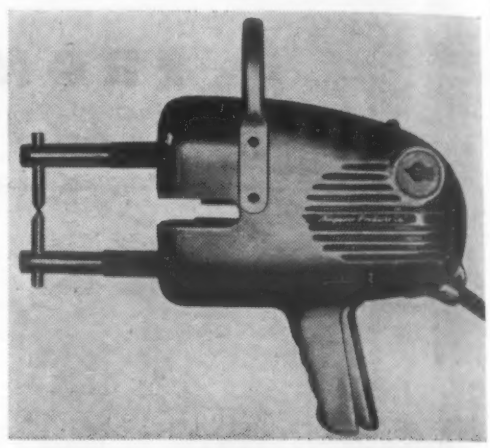
pyramidal diamond indentor, and is capable of giving accurate readings from softer than 0 to 64/69 Rockwell C, with good comparable results up to about 75 Rockwell C. With adjustable loads from 1 to 30 kgs, and with no clamps in front of the instrument, it can handle the smallest and thinnest pieces as well as large and odd-shaped items, the manufacturer says.



Portable Spot Welder Contains Electronic Timing Control

A portable spot welding machine, developed by *Ampower Products Co.*, 5737 W. 87th St., Oak Lawn, Ill., features an electronic timing control enclosed within the unit itself, thus elminating the necessity and expense of a wall timer. The timing control offers cycles ranging from 1/60 to 1 sec, allowing accuracy of adjustment.

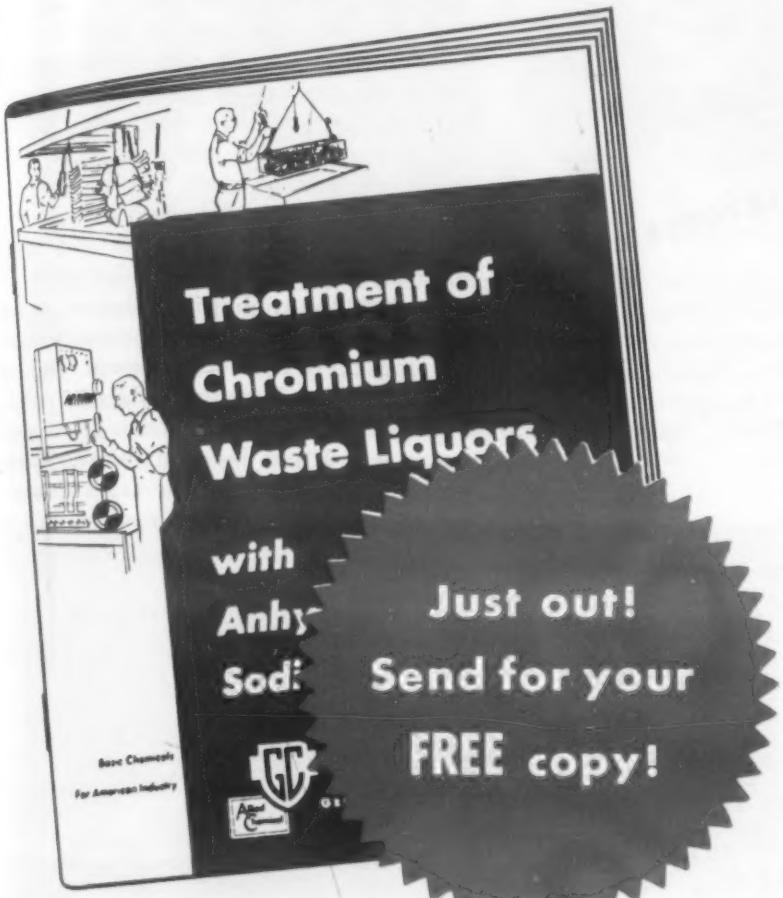
The machine's output is said to be over 10 kva, and it will weld most alloys of aluminum and steel, in addition to galvanized and cadmium plated sheets. The pistol grip increases ease of operation and handling, and it is said to be particulraly useful for work in places difficult to reach. The machine weighs 26 lb.

Also available is a stand onto which the welder can be mounted and used as a foot operated floor model suitable for semi-production work.

Cleaner Combines Minimum Toxicity with High Flash Point

Formulated to replace carbon tetrachloride in all cleaning operations, Turco-Solv combines the least toxic solvents available consistent with safety from fire hazard. Developed by *Turco Products, Inc.*, 6135 S. Central Ave., Los Angeles, the

LATEST INFORMATION ON PROVEN METHODS FOR TREATING *CHROMIUM WASTE LIQUORS!*



A "Must" for...

Plant Engineers and Operating Men... with chromium waste disposal problems.

General Chemical's new booklet provides *sound, practical* information on the use of Anhydrous Sodium Bisulfite. For example, it contains data on:

- Properties and characteristics of Anhydrous Sodium Bisulfite
- When and how to use Batch and Continuous treatments
- Flow diagrams for chromium waste treatment plants
- Materials of construction for waste treatment plants
- Latest testing methods

If you do Chromium Plating-Anodize Aluminum-Clean Brass, etc. You Need this Booklet!

General Chemical has long been one of America's foremost producers of Anhydrous Sodium Bisulfite, with a broad and thorough knowledge of the product, its properties and uses. As such, the company has assisted many organizations in the planning of their chromium waste treatment installations using Anhydrous Sodium Bisulfite. Much useful information based on this experience has been incorporated in a new booklet now available to plant engineers and operating men who have chromium waste disposal problems. It will prove a useful guide in setting up disposal plants using Anhydrous Sodium Bisulfite.

For those who wish to explore the problem more thoroughly, the services of General Chemical's Technical Service staff are available without cost or obligation. These experts are ready to assist plant operators in overcoming difficulties with the treatment of chromium wastes from plating, aluminum anodizing and brass-cleaning operations. Possibly they can help you with your disposal problems in the same practical way they have served so many other companies.

For Technical Service—or for further information on Anhydrous Sodium Bisulfite—write or phone the General Chemical office nearest you.

Allied Chemical

Don't Delay—Write For Your Free Booklet Today!

GENERAL CHEMICAL DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 Rector Street, New York 6, N. Y.

Gentlemen: Please send me AT NO COST OR OBLIGATION your free booklet "Treatment of Chromium Waste Liquors with Anhydrous Sodium Bisulfite."

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ADDRESS_____ MM-12

For more information, turn to Reader Service Card, Circle No. 309

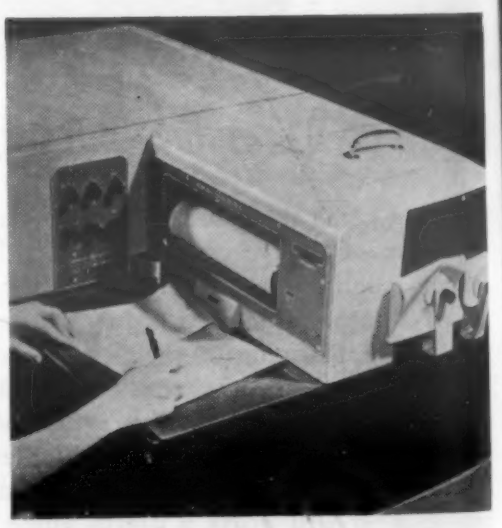
New Engineering Materials

quick-drying solvent is said to have a Tag Closed Cup flash point of over 200 F, making it applicable for cleaning of electrical equipment such as wiring, fuses, motors, switches, etc. Since it is non-conductive, Turco-Solv can be used to clean motors while they are still hot.

The company states that the solvent removes all deposits of grease, oil, metallic particles, carbon dust and other causes of dangerous and costly flashovers. It leaves no oily residues and requires no after-neutralization. It is non-corrosive and is safe for use on all metal and wood surfaces, as well as well-bonded paint.

Some of the applications claimed by the manufacturer are: in plant maintenance cleaning of electrical equipment, and on production lines) removal of grease pencil, chalk, ink or hand marks from motor generator sets. It can be used in whirl parts washers as a substitute for vapor degreasing or handwiping, or it can be used as a maintenance tool in the transportation field.

It is applied by non-atomizing, low pressure spray or brush.



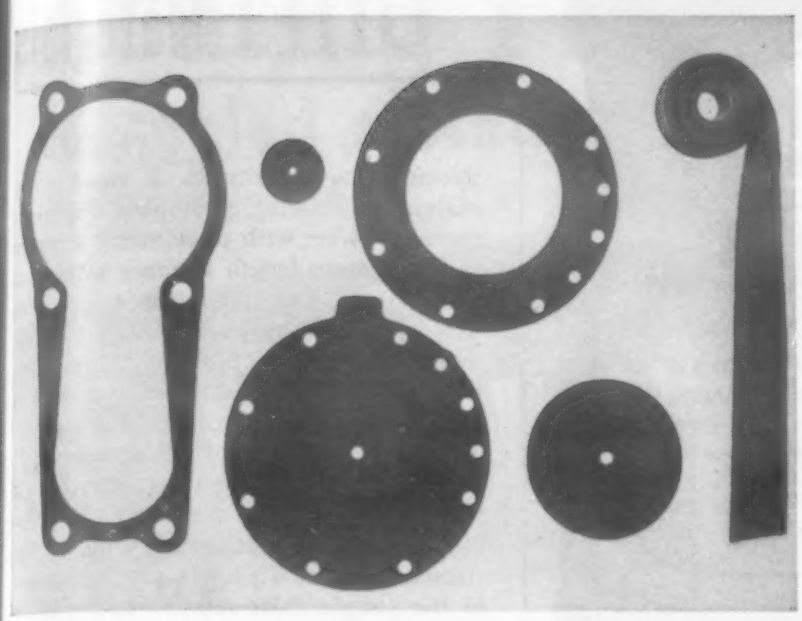
Recording Spectrophotometer Gives Quick, Accurate Readings

A redesigned recording spectrophotometer for industrial use in setting up standards to control the color of paints, dyes, glass, textiles, and other materials has been marketed by the *General Electric Co.'s Special Products Section,* Schenectady, N. Y.

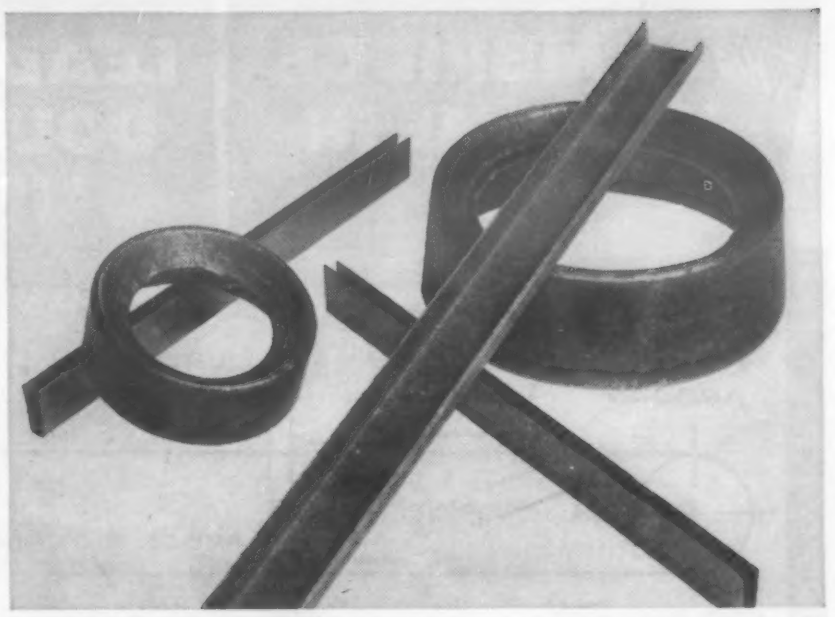
Previously used in laboratories for chemical, medical and pharmaceutical analysis, the G-E device was re-engineered with emphasis on accurate color measurement, greater sensitivity, and faster operation in order to increase applicability.

According to company engineers, the in-

Are any of these problems yours?

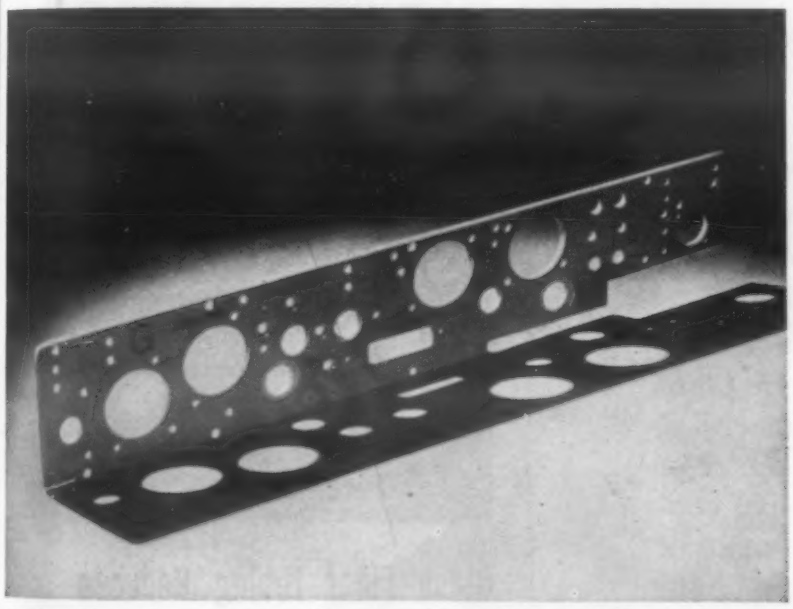


1. Need rubber-like properties for long periods of time under extreme temperatures? EMPIRE® Silicone Rubber Coated Glass Cloth (Class H insulation) is suitable for use over a temperature range of –70° F to 400° F . . . is resistant to thermal shock . . . will not crack, become brittle or deteriorate at high or low temperatures . . . offers good resistance to lubricating oils and most chemicals . . . has good dielectric strength and low power factor.

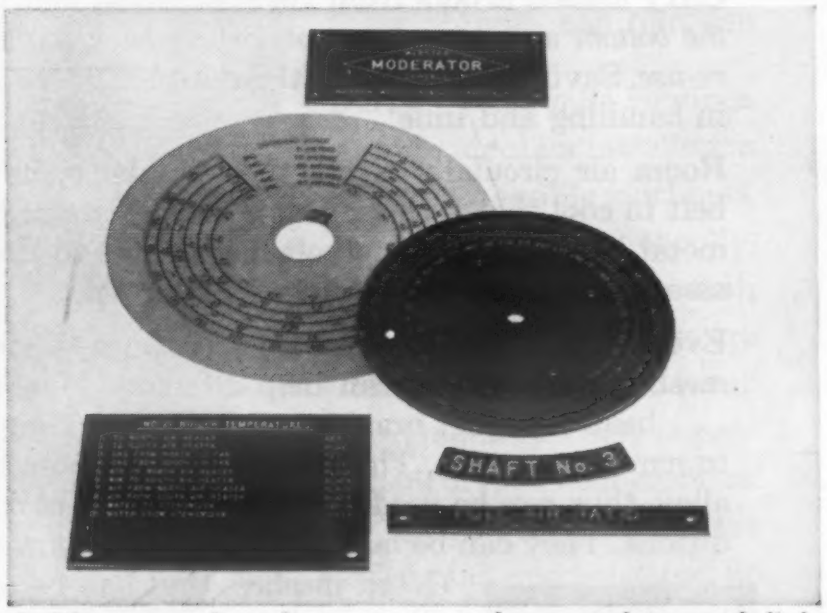


2. Looking for molding plate for Class H installations? Silicone molding plate for Class H applications which could not be produced successfully with regular built-up mica splittings can now be manufactured from ISOMICA* (built-up continuous mica sheets). ISOMICA silicone bonded molding plate has excellent moldability...excellent retention of shape...and an extremely high degree of homogeneity.

*Trade-mark



3. Looking for a versatile material with special mechanical, electrical and structural properties? LAMICOID®—a laminated plastic made with various fillers—is available in standard NEMA grades and others, with characteristics such as punching adaptability, heat and moisture resistance, tensile strength, impact strength, low loss factor, high dielectric strength, and properties "custom-made" to your specifications.



4. Want your signs, instrument panels, nameplates and dials to look better, last longer, be easier to install and maintain? DECORATIVE LAMICOID lends itself readily to marking by engraving, sandblasting, silk screen and rubber-plate printing, painting, filling or use of printed matter. Resists wear, aging, weathering, oils, corrosive vapors, moisture and temperature extremes. Wipes clean with a damp cloth.

Whatever electrical insulating materials you need, MICO makes them best. We manufacture all standard types and many special materials, or fabricate parts to your specifications. Send us your blueprints or problems today.

1893-1953 60 Years of Leadership in Electrical Insulation

MICO ELECTRICAL INSULATION

MICA *Insulator* COMPANY

Schenectady 1, New York

Offices in Principal Cities

LAMICOID® (Laminated Plastic) • MICANITE® (Built-up Mica) • EMPIRE® (Varnished Fabrics and Paper) • FABRICATED MICA • ISOMICA*

For more information, turn to Reader Service Card, Circle No. 356

New Engineering Materials

strument now furnishes a rapid color analysis by drawing a complete didymium curve in 54 sec with photometric accuracy of 0.5%, wave length accuracy within 1.0 millimicron, and photometric precision within 0.2%. A range of 380 to 700 millimicrons has been provided in anticipation of any new colorimetric standards which may be established by the International Commission of Illumination.

In measuring reflectance samples, a homogeneous sample is placed in the sample holder and a standard white in the standard holder. This will give a measure of the sample color relative to the white standard. After the paper is mounted on the recording drum, the operator turns on the wave-length drive and a complete curve is automatically drawn in 54 sec.

The three components of the 500 lb apparatus—the monochromator, photometer, and recorder—are housed in a single enclosing case measuring 45 by 26 by 19 in. Power requirement is 400 w at 115 v, 60 cycles.

Glass Fiber Tubing Reduces Weight of Aircraft Fuel Gages

A new rolled tubing, incorporating glass fiber cloth with a binding resin known as diallyl phthalate (DAP), is said to reduce the overall weight of an aircraft fuel gage system as much as 25%. According to the manufacurer, the tubing can be machined to closer tolerances, has lower moisture absorption and its dielectric properties have greater stability under temperature and humidity extremes than any other applicable material currently on the market.

Developed by *Simmonds Aerocessories, Inc.* of Tarrytown, N. Y., in conjunction with *Synthane Corp.* of Oaks, Pa., and the *U. S. Polymeric Corp.* of Stamford, Conn., the new material is now being used in Pacitron electronic fuel gage systems for military aircraft; however, the company anticipates that the tubing, due to its improved properties, will find broad applications in the future.

(Continued on page 172)

Bearing Performance Assured

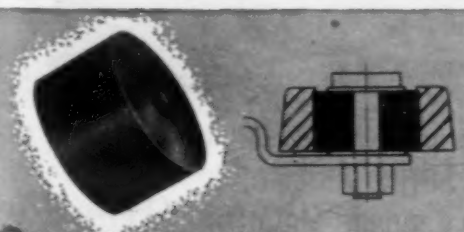
in sealed mechanisms and inaccessible machinery

MORGANITE
SELF-LUBRICATING
CARBON BEARINGS

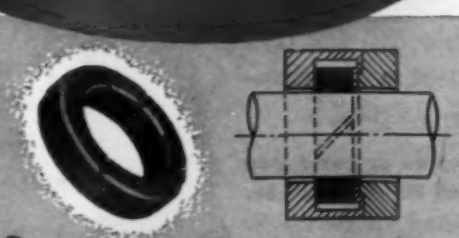
These 6 operating advantages reduce machine downtime, lower maintenance costs and increase production —

1. No lubrication required
2. No maintenance necessary
3. Elimination of cold start drag
4. Resistance to high heat
5. Self-lapping and polishing
6. Unaffected by most acids and corrosion

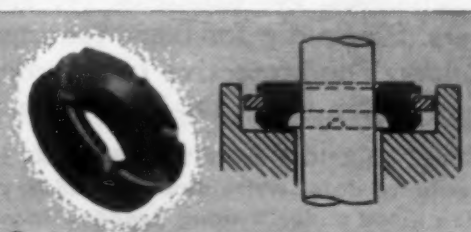
Durable Morganite Bearings are ideal for installation in inaccessible machines, and for use in hermetically-sealed mechanisms. As their self-lubricating qualities are inherent, and not a result of impregnation, they remain efficient at high temperatures. Because the bearings are self-lapping and polishing, no expensive finishes are necessary.



MORGANITE OUTBOARD BEARINGS FOR CONVEYOR ROLLER CHAINS—Withstand degreasing vapors, dipping bath fumes, high heat, water dip, steam, phosphoric acid spray. Self lubricating under all conditions including extreme changes of atmosphere and temperature.



MORGANITE TEXTILE BEARINGS FOR DYE VATS, IMMERSION ROLLS—Non-contaminating, non-warping, self-lubricating and long-lasting. Remain efficient in all dyes and bleaches with no ill effect to the bearing or the liquid. Will not contaminate chemical solutions.



MORGANITE SEAL NOSES FOR CIRCULATING PUMPS—Self-lubricating, leaktight seals — wet or dry — recommended for all types of pumps. Efficient with all fluids, immune to most corrosive acids and chemicals. For food machinery, fuel pumps, washing machines, automotive and marine engines.

IF YOU HAVE A DIFFICULT BEARING PROBLEM, CONSULT WITH US TODAY —

For complete information on your specific application, write Morganite. Recommendations will be supplied.

Morganite INCORPORATED

Manufacturers of SELF-LUBRICATING CARBON SPECIALTIES, CARBON BRUSHES AND CARBON PILES.

TRADE MARK

LONG ISLAND CITY 1, NEW YORK

For more information, turn to Reader Service Card, Circle No. 400

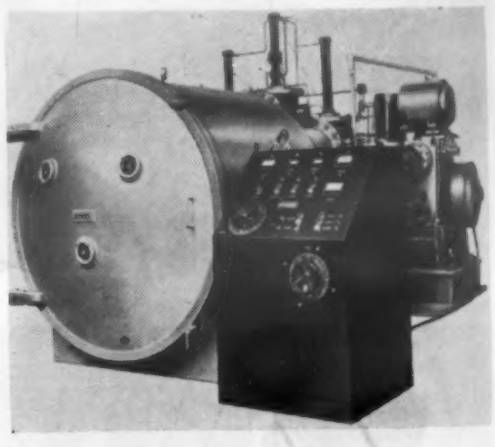
New Engineering Materials

New Neoprene Formulation Permits Fewer, Thicker Coats

By means of a new formulation, it is now possible to apply Neoprene in coats 0.010 to 0.020 in. thick, obtaining in 4 to 7 applications tank linings or coatings 1/16 in. thick. There is no loss of physical or corrosion resistance properties, and the coatings cure at room temperature.

Developed by *Carboline Div., Mullins Non Ferrous Castings Corp.*, 331 Thornton Ave., St. Louis, Mo., the heavy coat characteristic of the new product, called Neoprene 100, is said to combine pot life and corrosion resistance comparable with heat-cured Neoprene.

Another feature, in conjunction with the development of Neoprene 100, is the marketing of Neoprene 100 Primer which is suitable for both sandblasted and wire brushed rusty steel surfaces. The new primer is said to resist direct corrosion, creep corrosion, and to provide excellent edge protection. The Neoprene 100 coating will bond directly to it, and the primer can be modified for application on damp surfaces.



Large Automatic Vacuum Metallizer

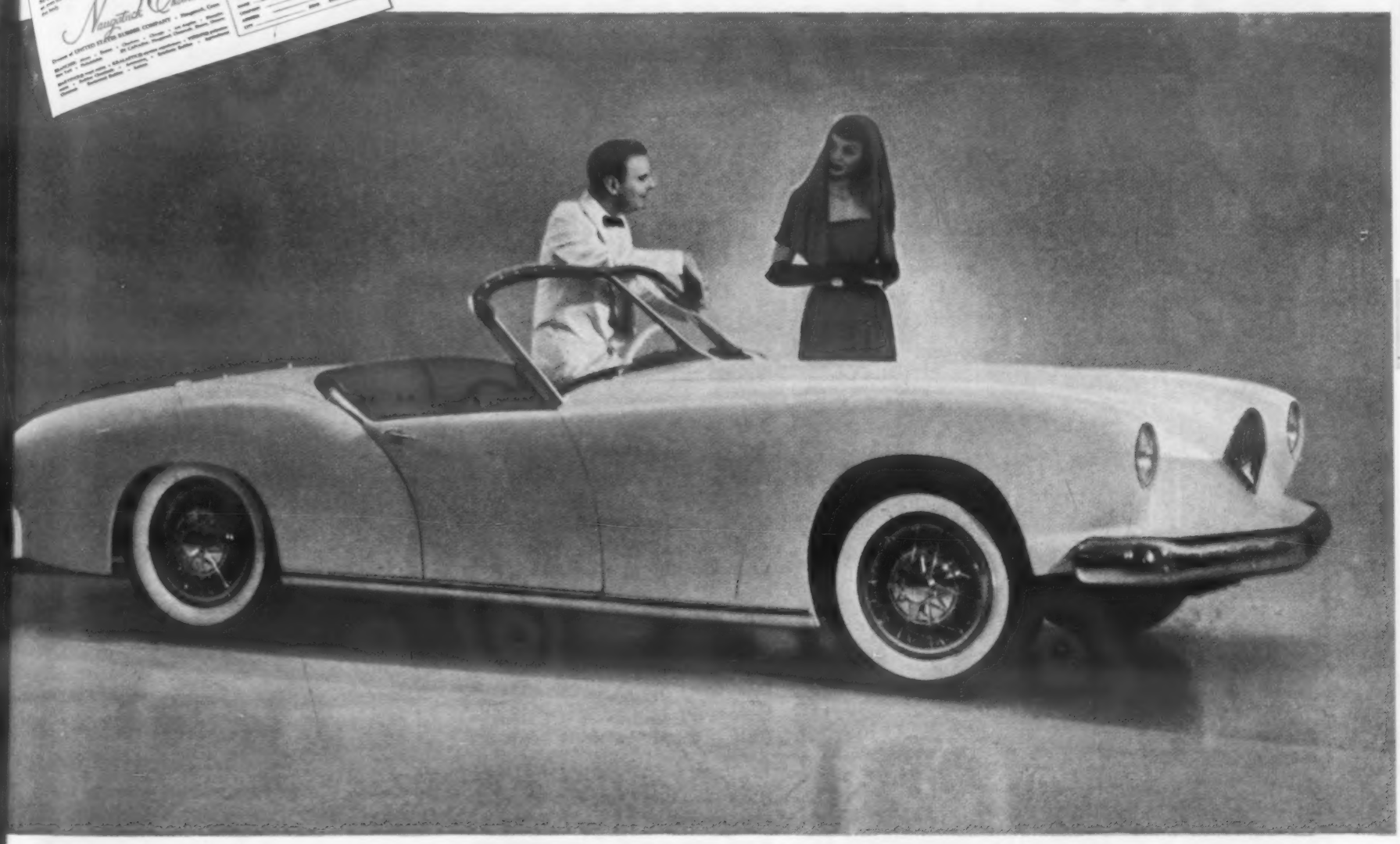
Compactness in the layout of the vacuum pumping equipment and automation of the control system with safety interlocks are features of the new 72 in. vacuum metallizing unit developed by the *F. J. Stokes Machine Co.*, Philadelphia, Pa.

Rapid pump-down of the chamber, which is 72 in. in dia and 60 in. long, is accomplished by a Stokes three-stage pumping system, made up of an 812-F, 500 cu ft per min rotary mechanical pump for roughing, a 147-D six-inch booster pump, and three 14-in. 147-E oil diffusion pumps. The three diffusion pumps are

For more information, Circle No. 323 ➤

MORE GOOD NEWS ABOUT...

Plastic Cars!



NEARLY TWO YEARS AGO, as the small ad reprint shows, Naugatuck announced the production of an experimental reinforced-Vibrin plastic car body—a body that was dent-proof, rust-proof, amazingly strong and light!

And now Kaiser Motors Corporation has begun to produce a Vibrin-bodied car for the public—the breath-taking Kaiser-Darrin being admired above!

Good news? You bet! Look how the Alembic I, Naugatuck's experimental car, has fared in over 45,000 miles of grueling road tests—equal to almost **twice around the world!**

In two years' time, the amazing Alembic I...

- sped along highways, jounced and twisted through torturous back roads from coast to coast, Texas to Canada.
- withstood burning desert sun, snow, sleet, and rain.
- had a fender scraped in Philadelphia.
- was rammed while entering a driveway.
- overheated from a broken fan belt till the hood became too hot to touch.
- took roughly **2½ times the wear and tear** the average car is subjected to in that time—in the hands of at least 100 drivers!

And Vibrin came through unharmed! A dab of paint for the fender scratch, a slight change in body mounting, and the body was better than ever!

No wonder reinforced Vibrin has risen to the very top of the "most promising materials" list...not only for car bodies, but for structural applications of all kinds!

To learn more about Vibrin® bodies, write us on your letterhead for the Story of Alembic I.

...n-Fiberglas bodies for Kaiser-Darrin (Main Illustration) molded by Winner Mfg. Co., Trenton, N. J., Lunn Laminates, Huntington Sta., L. I., and Ashtabula, O., Molded Fiber Glass Body Co., Ashtabula, O.

Naugatuck Chemical

Division of United States Rubber Company

112 ELM STREET, NAUGATUCK, CONNECTICUT

...RANCHES: Akron • Boston • Charlotte • Chicago • Los Angeles • Memphis • New York • Philadelphia. IN CANADA: Naugatuck Chemicals, Elmira, Ont.

New Engineering Materials

directly connected to the rear face of the metallizing chamber, without a manifold.

Solenoid-controlled air-operated poppet valves of the disc type are installed in the vacuum lines from the chamber to each of the pumps. The valves are remotely controlled from the panel of the control cabinet at the front of the unit. The pumping system, working as a unit, can evacuate the empty chamber to a pressure of ½ micron (normal working pressure for metallizing) in 7 min.

Sequence of Operations—Pushing the No. 1 button to start the rough pumping automatically closes all the valves opening from the vacuum chamber except the one to the mechanical vacuum pump. When the rough vacuum pressure gage reads 200 microns, the operator pushes the No. 2 button, which closes the valve from the chamber to the roughing line and opens the three valves to the diffusion pumps and the smaller one to the booster pump.

When the pressure has been reduced to ½ micron, the chamber is ready for flashing the filaments and depositing the metal coating on the parts to be plated. The filament-heating current can be raised to the flashing-point and held there for the proper length of time either by an automatic flashing cycler or by manual control.

After metallizing is complete, the operator pushes the No. 3 button which closes all the valves leading out of the chamber and, after allowing ample time for all the valves to close, trips another valve admitting air to the chamber. This precaution is said to safeguard the diffu sion pumps against oil contamination and oxidation

---

Spray Enamel Has Color-Flecked Finish

A wide range of applications is claimed for Plextone, the new color-flecked enamel finish produced by *Maas & Waldstein Co.*, Newark, N. J. The finish is said to have endless color possibilities, from tones-on-tone to brilliant spatter effects in a wide range of colors, sprayed from one gun at one time.

The company states that among the surfaces on which the enamel may be applied are wood, wallboard, composition materials, paper, plaster, plastics, woven fabrics, cast iron, steel, aluminum, brass, copper and zinc. It is said to be particularly useful in finishing porous materials which tend to absorb ordinary finishes.

For most surfaces, no more than one prime coat and one Plextone coat are required. The textured finish covers wood

(Continued on page 178)

For more information, Circle No. 349

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributors: Bethlehem Steel Export Corporation

Bethlehem's large tool steel depot carries a complete range of sizes in 24 different grades of steel, to facilitate rapid shipment to distributors.

Prompt Service?
ee Your Tool Steel Distributor

g Johnny-on-the-spot is but one many services performed by the steel distributor. He knows what's ded in your area, and to make sure r requirements are met promptly, eeps large stocks of tool steel on d. You'll find him always ready to d you a helping hand, too, whether require a simple operation like ting bars, or something much more plex, such as determining the kind heat-treatment needed.

It's all to the good when you have a tool-steel distributor near you, for then it's not necessary to carry large inventories. What's more, the distributor often has a supply of other steel specialties that you may need.

All distributors of Bethlehem Tool Steels are friendly, reputable firms, well known for their good service. They're good people for you to know. Our hat is off to them for a fine job — each and every one.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Don't Use Fresh Water for Quenching Tools

makes no difference what the source y be—fresh water is simply unsuit- e for the quenching of tools. For fresh water contains dissolved es, which are released at the sur- e of the tool when it is quenched. e small gas pockets thus formed can vent contact between the tool and ter, and the resultant ineffective nch causes soft spots. These soft spots are likely points for cracks to occur in the tool.

A good way to avoid this trouble is to quench in water which has been boiled to remove the dissolved gases. Suppose the water cannot be boiled? Then expel the gases by quenching a large amount of hot "dummy" material. Even better would be a 10 pct brine solution, made up using degassed water.

New Booklet on Bearcat Tool Steel

We recently issued an attractive 2-color booklet on Bearcat Tool Steel — the versatile general-purpose steel that is so well suited for applications involving high shock-resistance. The 8-page illustrated booklet contains a wealth of information about Bearcat — goes into considerable detail about its hot-work and easy-machining properties.

Bearcat is a super steel in every respect. It is air-hardening, thus minimizing quenching hazards, and it has good resistance to distortion during heat-treatment.

OTHER ADVANTAGES OF BEARCAT

In addition to superior shock-resistance, Bearcat has these other important advantages:

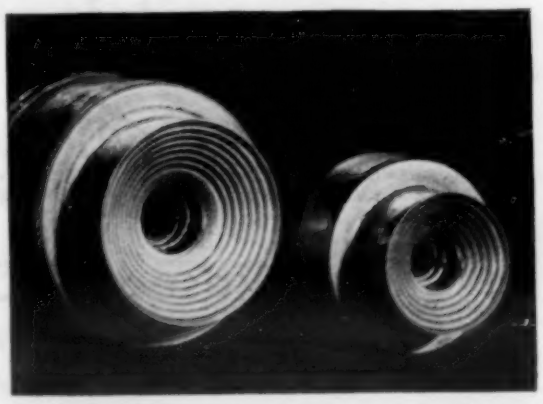
1. Deep hardening
2. Easy machining (Brinell 197 max)
3. Low distortion in heat-treatment
4. Good hot-work properties
5. Easily carburized for long wear

TYPICAL ANALYSIS

C	Mn	Si	Cr	Mo
.50	.70	.25	3.25	1.40

Bearcat is especially recommended for both hot- and cold-shock applications such as rivet sets, chisels, punches, hot headers, and gripper dies. It is also ideal for short-run dies used in cold-forming, blanking, and bending, as well as for engraving dies, die-casting dies, and master hobs. It has many other uses, too.

It will be worth your while to look into Bearcat. Why not talk it over with your Bethlehem tool steel distributor? And of course you'll want to read the new booklet on Bearcat. Write to the Publications Dept., Bethlehem Steel Company, Bethlehem, Pa. Ask for Booklet 341.



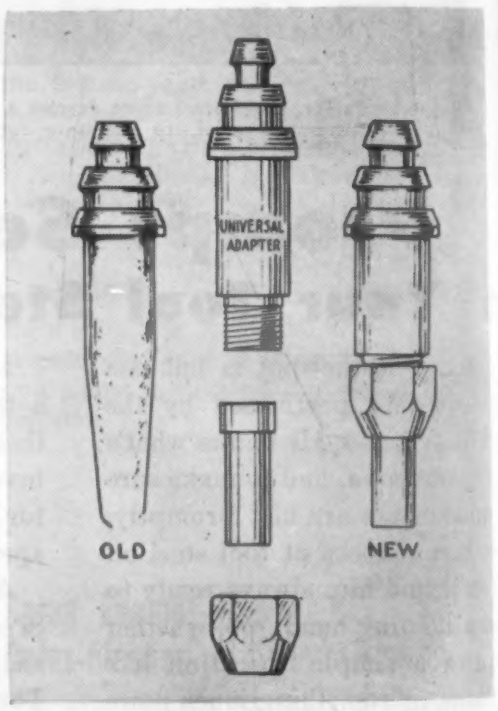
Here's a typical use for Bearcat — general-purpose dies requiring a high degree of toughness. These dies are used to produce aluminum impact-extrusions.

New Engineering Materials

knots, metal spot welds, flaws and blemishes, and cuts material waste, since less costly base materials may be used. The finish can be applied with ordinary spray equipment and techniques.

Durability tests on the finish have shown that it is resistant to chipping, cracking and abrasion. It is not affected by alcohol, grease or oil and is chemically resistant. It can be washed, scrubbed and scoured with abrasive cleaners without surface damage. Spots that have been retouched are impossible to detect, the company says.

Plextone has a lacquer base and air dries in about 30 min; it is normally hard enough to handle in 2 to 3 hrs. Flat or semi-gloss sheens are available, or there are combinations giving glossy highlights on flat backgrounds.



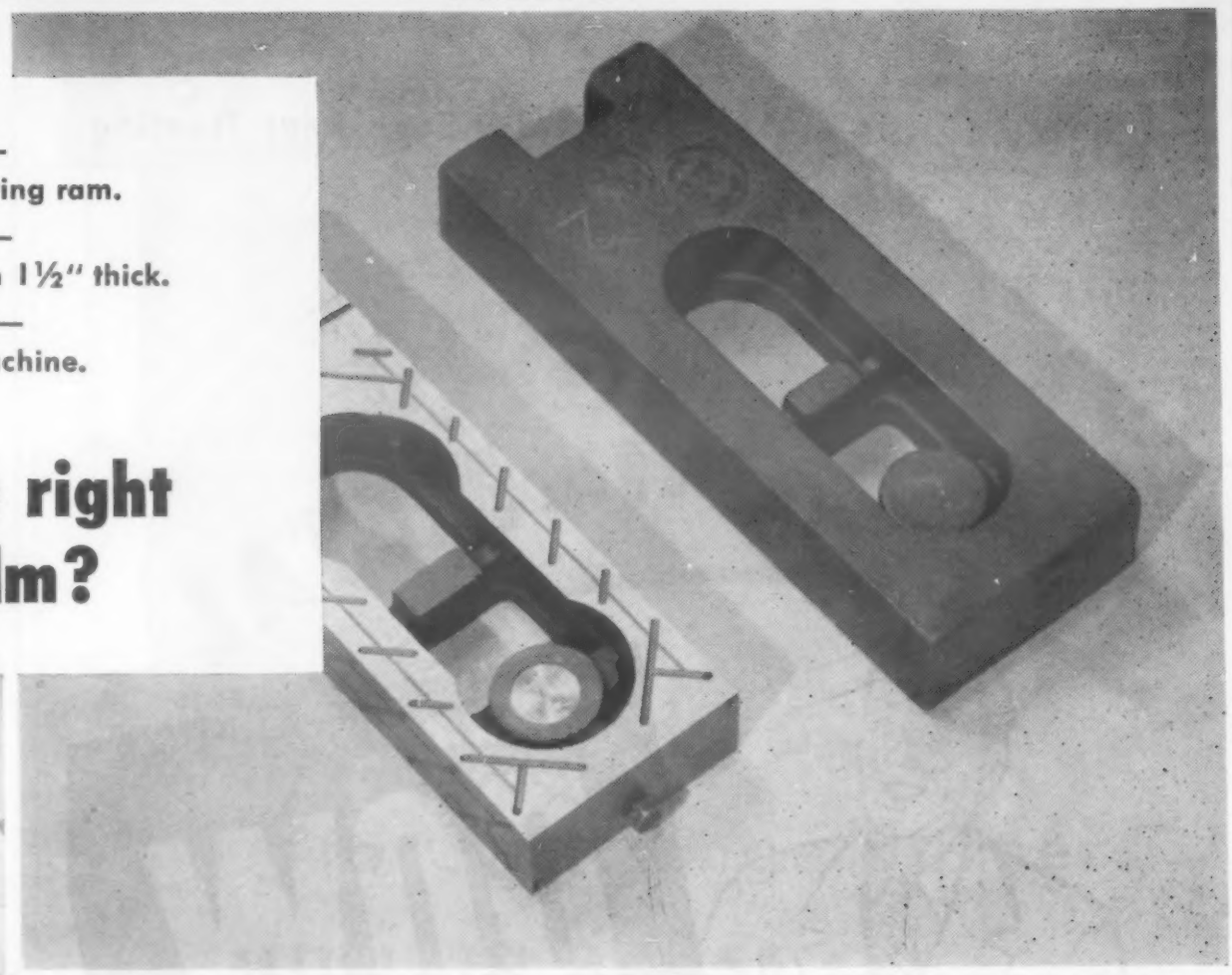
Interchangeable Tip Ends for Cutting Torches

Use of a new type welding tip end and adapter is said to eliminate the need for constant replacement of welding tips, and reduce the gas and oxygen consumption of cutting torches.

Marketed by the *Evans Machine Co.*, 122 S. Calverton Rd., Baltimore, Md., the Universal Cutting Tip Ends are interchangeable and will fit any cutting torch with the use of the Universal Adapter, which becomes a part of the torch. In order to renew the cutting tip, only the tip end must be replaced.

According to the manufacturer, the three-piece construction facilitates cleaning and assures longer life.

For more information, Circle No. 330 ➤



PRODUCT—
Casting for reciprocating ram.
MATERIAL—
High-strength cast iron 1½" thick.
EQUIPMENT—
220 kv x-ray machine.

What's the right X-ray film?

KODAK INDUSTRIAL X-RAY FILM, TYPE K

This casting, worth about $2, is headed for machining, heat treating and scraping worth $375. It's no time to take a chance on hidden faults.

So the radiographer checks each casting and discards the unsound.

For these radiographs he uses 220 kv at a distance of 40 inches, lead screens, and Kodak Industrial X-ray Film, Type K—the right choice for this thickness of iron and x-ray equipment.

THERE'S A RIGHT FILM FOR EVERY PROBLEM

Whatever your radiographic problem, you'll find the best means of solving it in one of Kodak's four types of industrial x-ray film. This choice provides the means to check castings and welds efficiently, offers optimum results with varying alloys, thicknesses and radiographic sources.

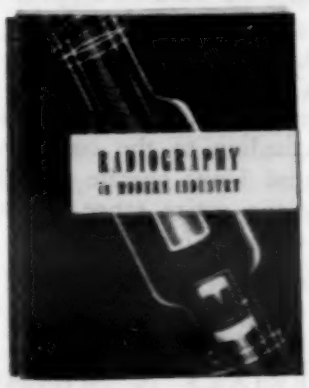
Type K—has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed at available kilovoltage, without use of calcium tungstate screens.

Type A—has high contrast and fine graininess with adequate speed for study of light alloys at low voltage and for examining heavy parts at intermediate and high voltages. Used direct or with lead-foil screens.

Type M—provides maximum radiographic sensitivity, with direct exposure or lead-foil screens. It has extra-fine grain and, though speed is less than Type A, it is adequate for light alloys at average kilovoltages and for much million- and multi-million-volt work.

Type F—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays when exposed directly or with lead screens.

Radiography... another important function of photography



RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practice, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get a copy from your local x-ray dealer—price, $3.

EASTMAN KODAK COMPANY
X-ray Division · Rochester 4, N. Y.

Kodak
TRADE-MARK

New Engineering Materials

New Bright Copper Process

A new bright copper process which is said to increase plating production as much as 60% has been developed by *Smoothex, Inc.*, Cleveland, Ohio. Developed because of the government allocation of nickel, the Smoothex Bright Copper Process is said to be fast, easy to control, economical and adaptable for both large scale and job shop production.

The process is said to be 98% efficient, has high speed of deposition, and good throwing power. Ductile deposits and low copper concentrations are featured in the process, and periodic reverse or intermittent current may also be applied.

Control Unit for Metal Heating Operations

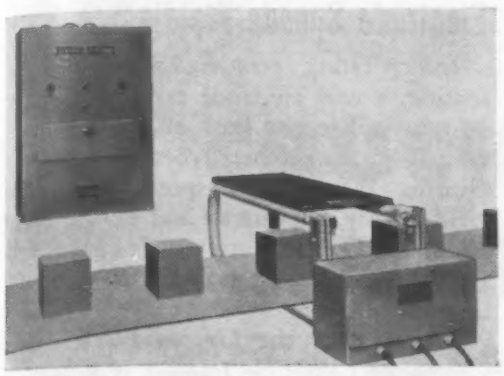
The new Cincinnati Flamatic Power Control Unit, comprising a central unit for precise control of fuel gas and oxygen for various selective heating operations, has been marketed by the *Cincinnati Milling Machine Co.*, Cincinnati. Ohio.

The unit, in addition to controlling fuel gas and oxygen, controls pressure of water for cooling and quenching, air for actuating cylinders and electrical power for automatic work movement and operational cycling.

Three sizes are furnished, with 2, 4, and 6 mixed gas circuits respectively. The No. 3 Unit, the largest furnished at present, has a maximum capacity of 4500 Btu per hr, the equivalent of 1320 kw per hr. According to the company, the Power Control Units operate at full efficiency over the entire range of outputs from zero to maximum.

(Continued on page 181)

New Engineering Materials



Metal Detector Designed for Conveyor Belt Work

A general-purpose metal detector which can be installed around conveyor systems without cutting the belt and can be adapted to special applications has been marketed by *General Electric Co.'s Special Products Section,* Schenectady 5, N. Y.

The equipment consists of an electronic cabinet and an inspection coil system. The control cabinet contains electronic components and bridge circuits which are completely enclosed. Mounted on the outside of the door are controls and indicators for operation of the equipment. The coils are 1½-in. dia aluminum tubes and are attached to heavy aluminum straps on the junction box. They may be slipped over a conveyor type installation and then bolted to the junction box without disturbing the conveyor system. Two standard coil sizes are available: one rectangular coil with inside measurement of 33 by 10 in., and the other a circular coil with a 4-ft diameter. Special sizes can be furnished on request.

In operation, the G-E device detects metal by perceiving the effect of the metal particles on the characteristics of an inductance bridge circuit. The coils which make up the inspection unit are elements of this bridge circuit, and a metal particle coming into the inspection aperture causes the bridge to become unbalanced electrically. The output (or unbalance signal) of the bridge is then amplified and used to operate an alarm or control.

The device is said to be applicable to mining field operations since the equipment can be installed under adverse conditions and be used to detect metals in non-magnetic and non-conductive types of ore. In industrial food operations the detector will reveal metal particles in many packaged food products, and in the paper and lumber industries, the detecting component can be immersed in the log pond and logs floated through for a metal inspection.

Power requirements are 105/125 v, 60 cycles, 150 w.

New Engineering Materials

Powdered Metal in Coating of Drag Electrode Speeds Welding

Incorporating powdered metal in the coating, a new electrode called Jetweld is said to utilize the heat of the arc more efficiently than other types, thereby increasing the welding speed, with high weld quality, appearance and ease of operation. Typical welding speeds on lap and fillet work are on the order of 12 to 15 in. per min.

Marketed by the *Lincoln Electric Co.*, Cleveland 17, Ohio, Jetweld is a heavily coated shielded-arc type of electrode for operation in flat or near flat positions with a.c. or d.c. welding current. It meets the physical requirements of class E-7016 and is used on work formerly calling for E-6012 and E-6020 electrodes on single or multiple pass welds. It is especially well suited for horizontal and flat position fillets, horizontal and flat positions laps, single and multiple pass butts, deep grooves and corners, and cover pass on multiple pass butts.

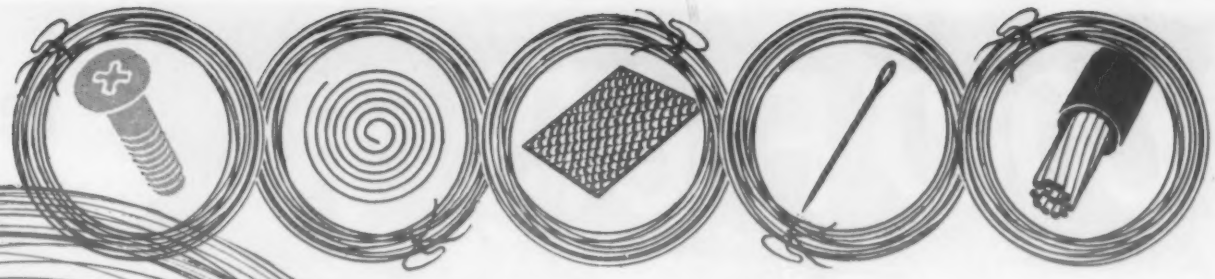
According to the company, it is particularly suited for welding some higher carbon steels without cracking and without surface holes. Weld metal is said to be uniform x-ray quality, free from undercut with high impact values. Typical physical properties, as welded, are: Tensile strength, 93,000 psi; yield point, 79,000 psi; elongation in 2 in., 15 to 22%; Charpy keyhole impact value at room temperature 28 ft lbs.

The new electrode is 5/32, 3/16 and ¼ in.

Iron-Rubber Sheets Resist Abrasion

Marketed by the Magic Chemical Co., Brockton, Mass., a new protective sheeting called Iron-Rubber is said to give abrasion and corrosion resistance to many types of industrial equipment. According to the company the sheet will minimize maintenance costs, increase the life of equipment, and increase production by eliminating shutdowns for repairs. It is designed for use on chutes, hoppers, ball mills, ducts, pipes, skips, housings, tanks shaking tables, shot and sand blast cabinets, or other equipment normally subjected to excessive wear.

The sheeting is available in two types, reinforced and non-reinforced. The reinforced Iron-Rubber is composed of two sheets of rubber permanently bonded to a



CRUCIBLE FINE STAINLESS WIRE...

now available — all sizes . . . all tempers

Users of fine wire can now obtain prompt delivery of Crucible stainless steel wire . . . in all diameters . . . in all tempers from full hard to dead soft. And Crucible's fine wire comes in all standard grades — with a bright surface or a variety of metallic and nonmetallic finishes tailored to meet your specific application.

Our new fine wire mill is equipped with the latest facilities for annealing, pickling, drawing and finishing. Our mill metallurgical control setup is the latest word, too, to assure you that every spool and coil produced conforms to Crucible's high standard of quality — dimensional, physical and surface uniformity that is unsurpassed in the industry.

No matter what type of wire you use — whether it be cold heading wire, weaving wire, spring wire, needle wire, screen wire, cable wire, or a host of other types — our new mill is equipped to serve you. For prompt delivery of quality stainless wire, call your nearest Crucible warehouse.

CRUCIBLE first name in special purpose steels

53 years of Fine steelmaking

STAINLESS STEEL WIRE

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

REX HIGH SPEED • TOOL • REZISTAL STAINLESS • MAX-EL • ALLOY • SPECIAL PURPOSE STEELS

For more information, turn to Reader Service Card, Circle No. 383

New Engineering Materials

central core of expanded steel. This type can be bent to fit corners or can be shaped to fit any contour. Non-reinforced is a single sheet of rubber.

Hard-Facing Electrode Provides Increased Rate of Deposition

A new electrode suited for hard-facing various types of industrial equipment has been marketed by the *Stoody Co.*, Whittier, Calif. Coated Tube Stoodite, known during field testing as Experimental Electrode, Stoody 1293, has as its principal alloys chromium and molybdenum which are said to provide good resistance to all types of arbrasion, a high compressive strength and excellent impact resistance.

The electrode is weldable to all carbon and alloy steels including manganese. Deposits are semi-austenitic and are not affected by ordinary heat treating methods. Under normal welding procedure, either a.c. or d.c., deposits show a Rockwell C hardness of 56 to 60, and properties are retained at temperatures up to 800 F.

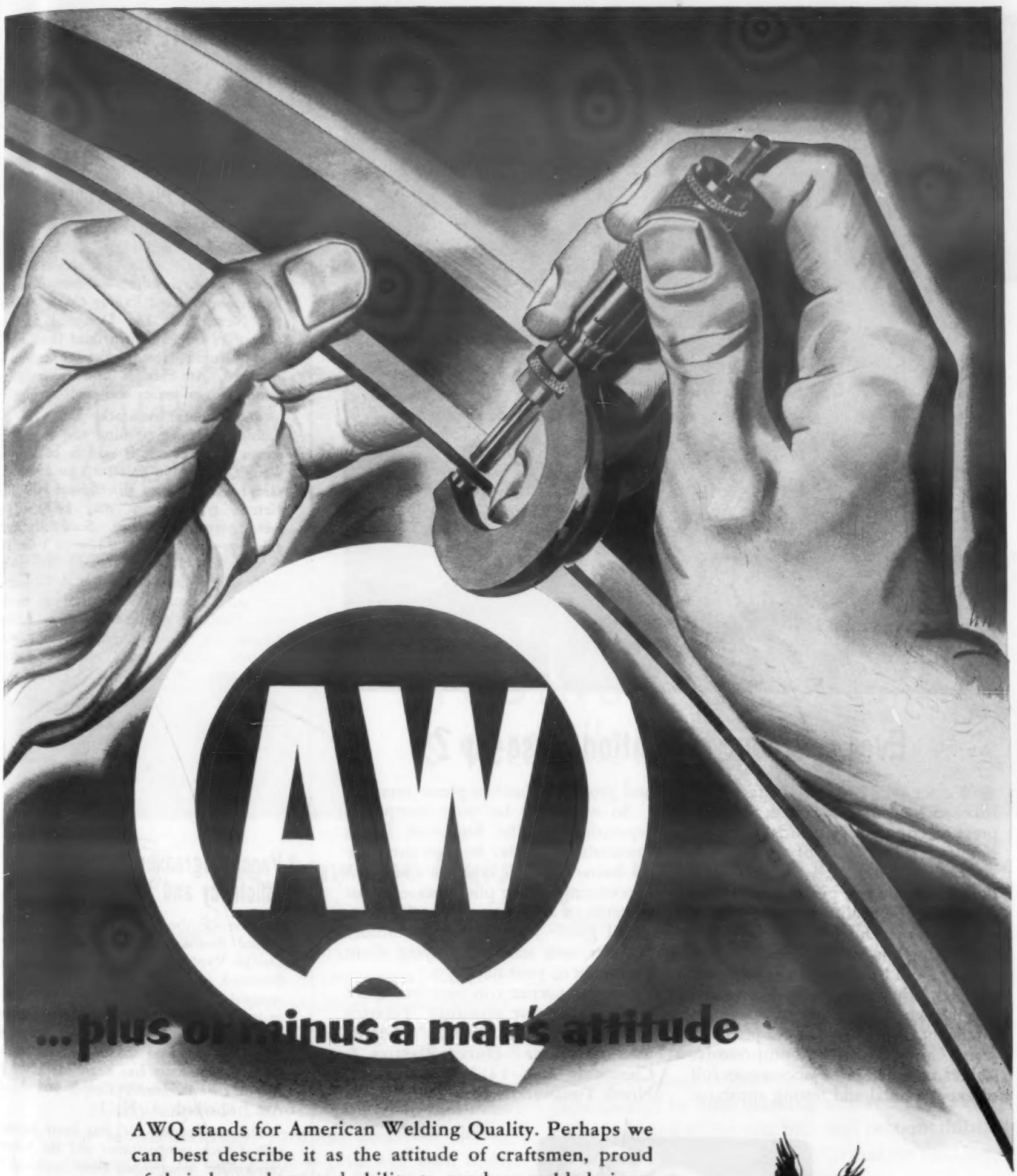
New Rod for Repair of Manganese Steel Castings

A manganese-nickel steel welding rod for repairing or building up worn or broken manganese steel castings has been marketed by *Wall Colmonoy Corp.*, 19345 John R St., Detroit. It can also be used as a build-up material prior to applying Colmonoy hardfacing alloys to manganese steel parts.

Called Walmang, the alloy was developed to provide an austenitic manganese steel welding rod that produces weld metal having the same manganese content, work hardenability, and wear resistance as cast 12% manganese steel. The weld deposits have an initial hardness slightly less than the 160-190 Brinell hardness of the parent manganese steel casting, but it will work harden in use under deformation and impact to 450 Brinell and higher, the company claims. The deposit is also said to have strength and ductility approaching that of the parent metal.

The bare rod can be applied with d.c. equipment, while the coated rod can be used with either d.c. or a.c. equipment. The rods are available, either bare or coated, in 1/4, 3/16, 5/32, and 1/8 in. dia sizes.

(Continued on page 186)



AWQ stands for American Welding Quality. Perhaps we can best describe it as the attitude of craftsmen, proud of their know-how and ability to produce welded rings, bands and welded assemblies . . . or to be more specific, craftsmen who treat every job with the same degree of care that you insist upon in your own plant.

If your requirements involve either fusion or resistance welding of ferrous or non-ferrous metals, call or write us. We can put our 35 years of welding experience — the latest techniques and equipment—and 1600 conscientious hands to work for you.

THE AMERICAN WELDING & MANUFACTURING COMPANY • WARREN • OHIO

For more information, turn to Reader Service Card, Circle No. 483

New Engineering Materials

Transparent Plastic Tubing

An all-purpose, transparent plastic tubing which is said to be resistant to most inorganic acids and alkalis and to many organic chemicals has been marketed by *American Hard Rubber Co.*, 93 Worth St., New York 13. Designed for any temporary or permanent fluid lines where easy-to-handle, sturdy, flexible tubing is required, Ace-Flex is said to be inert, odorless, non-toxic, and well-ageing.

The smooth, non-tacky finish of the tubing simplifies cleaning and it may be steam sterilized. It is said to be light in weight, abrasion-resistant, and retains clear transparency throughout its life. Ketone type cement may be used to weld permanent joints. Standard available sizes range from 0.120 to 1 in. i.d.

Suggested applications for the tubing include chemical and medical laboratory tubing, surgical tubing, electrical insulation, conduit, grommets, battery tubing, tubing for coolant systems, lubricating systems, paint sprayers, air lines, instrument tubes, etc.

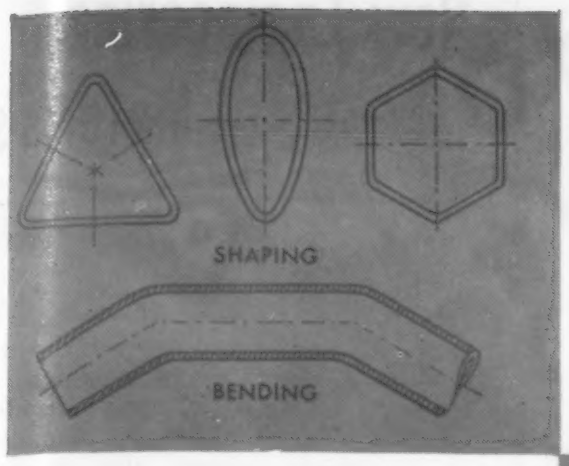
Vapor Degreaser Redesigned for Efficiency and Versatility

Some of the features said to be included in the new Metalwash Improved Design Vapor Degreaser are: obstruction-free tank walls, recessed condensing coils, removable pump chamber and water separator made of solid stainless steel, one-end maintenance, and demand type control of water into the water condensing system. The unit has been marketed by *Metalwash Machinery Corp.*, 901 North Ave., Elizabeth 4, N. J.

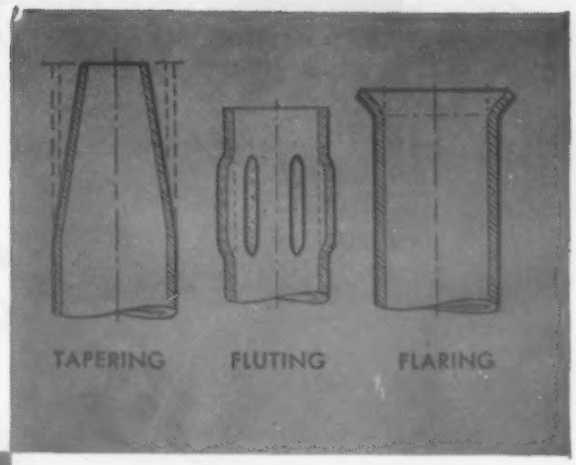
The condensing coil has been recessed into a back compartment and the solvent condensate trough has been replaced by a large sloped condensate tray also recessed and directly underneath the condensing coil.

The over-size water separator and pump compartment have been fabricated of solid stainless steel and welded to a flanged plate to permit removal of the complete unit allowing periodic inspection of the storage tank interior. This design permits the customer to convert the straight vapor degreaser to a vapor spray degreaser.

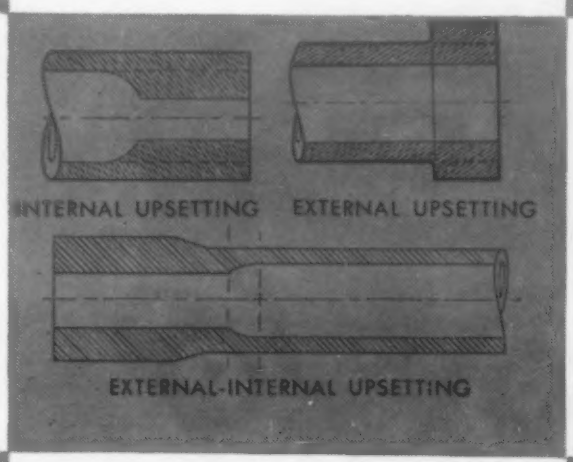
All service connections and clean-out openings are located at one end of the tank allowing the unit to be placed in a corner of the room; all service may then



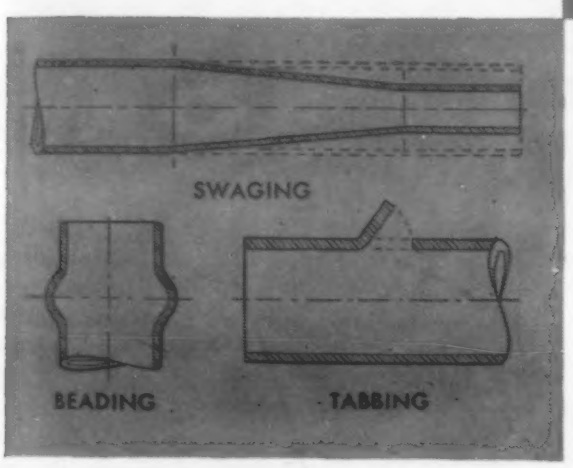
OSTUCO TUBING is versatile!



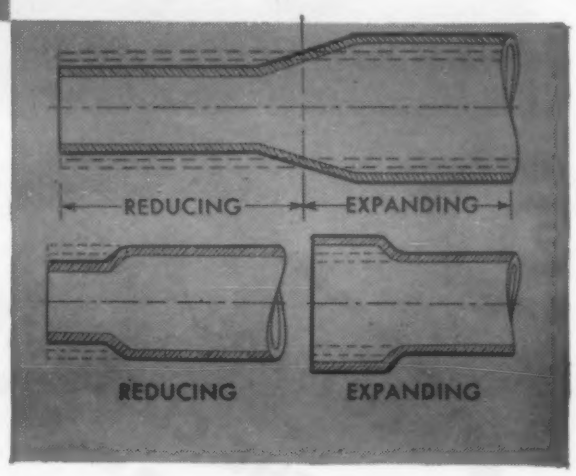
OSTUCO TUBING is versatile!



OSTUCO TUBING is versatile!



OSTUCO TUBING is versatile!



you draw the blueprint . . . we'll deliver the goods

There's practically no limit to the things OSTUCO can do with Seamless and Electric Welded Steel Tubing to help you produce lighter, stronger, better looking products at lower cost. Only a few of the operations are shown above.

Newly expanded and modernized facilities for *manufacturing, forging,* and *fabricating* tubing, all in one plant — plus our own steel source as a member of the Copperweld family —speed deliveries, assure highest quality and save you money.

Tubing is our business, not a side line. OSTUCO's unique "Single Source" operation, with unified production control, eliminates shipments from one location to another . . . greatly reduces rejects . . . prevents errors . . . puts an end to buck passing and red tape. You write one order, get one bill, and responsibility is clearly fixed. Write for informative catalog, "Ostuco Tubing."

OHIO SEAMLESS TUBE DIVISION
of Copperweld Steel Company
Manufacturers and Fabricators of Seamless and Electric Welded Steel Tubing
Plant and General Offices: SHELBY, OHIO

OSTUCO SHELBY, OHIO

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New Engineering Materials

be accomplished without moving the tank from its original position. The water condensing system, when used with a properly located automatic water temperature regulator, minimizes the formation of atmospheric moisture, thus reducing the possibility of hydrolysis with the degreasing solvent.

The automatic water temperature regulator is so installed that maximum water is required only at times of maximum heat input, when no work is being cleaned. Work introduced into the degreaser results in the regulator throttling down so that only the proper amount of water is sent through the cooling system. According to the company, this may reduce the water consumption as much as 75%.

New Alnico Alloy Offers High Energy Product

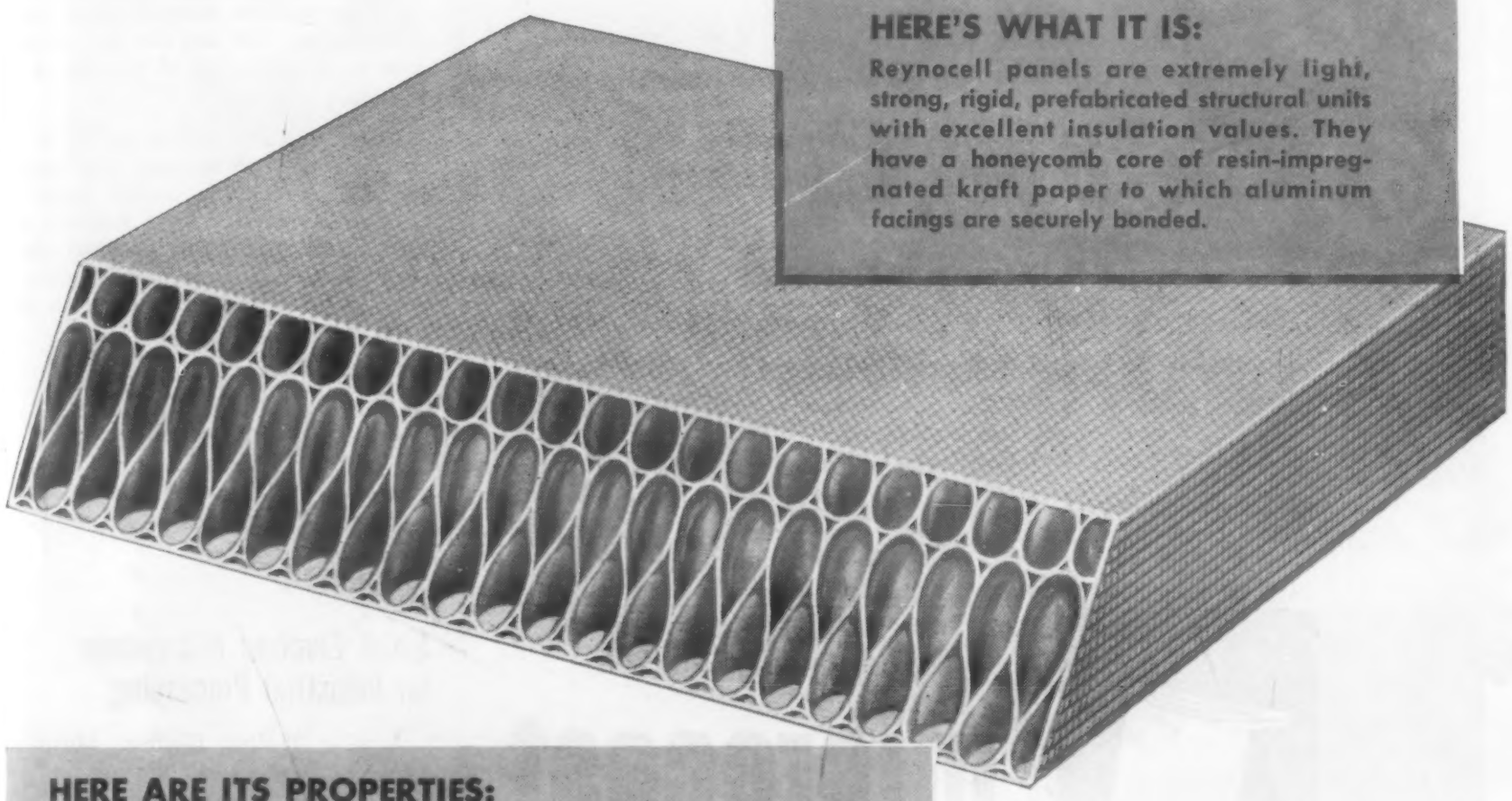
A new Alnico alloy offering an energy product of 5.70 x 10^6 Bd Hd and designated Alnico 5Cb has been developed by *Thomas & Skinner Steel Products Co., Inc.*, Indianapolis. According to the company the new alloy is similar to Alnico 5 in physical characteristics but offers considerably higher external energy and residual reduction. It is designed for electrical, electronic and industrial applications where weight and space reductions might be of advantage in product design.

Reverberatory Furnaces for Aluminum, Brass, and Magnesium

Two new reverberatory furnaces for aluminum, brass and magnesium have been developed by *D.C.M.T. Sales Corp.*, 164 Duane St., New York. The DCMT AR/200 and the DCMT AR/500 have capacities of 200 and 500 lbs of aluminum respectively. They take up a minimum of floor space and heat control is accomplished through an air control valve to the combustion chamber. This will in no way affect the atmosphere in the furnace, which is preset upon installation via a flue gas analysis, the company claims.

The use of a reverberatory type furnace effects a saving in gas consumption over a crucible type furnace since no heat is lost through radiation from the open surface of the metal. In addition, the flame is directed on the metal itself rather than heating a pot which in turn heats the metal.

INTRODUCING REYNOCELL†



HERE'S WHAT IT IS:

Reynocell panels are extremely light, strong, rigid, prefabricated structural units with excellent insulation values. They have a honeycomb core of resin-impregnated kraft paper to which aluminum facings are securely bonded.

HERE ARE ITS PROPERTIES:

(Typical, based on 4" thick panels. Comparably favorable properties apply to other thicknesses.)

Weight—1.46 lb/sq ft
Bending Strength—180 lb/sq ft of uniformly distributed load on 8′ span
Deflection—¼" with 47 lb/sq ft of uniformly distributed load on 8′ span
Crushing Strength—70 psi
Thermal Insulation (U factor)—.135
Sound Transmission Loss—31 decibels
Fire and Moisture Resistant—Fungus and Pest-Proof

WHERE CAN *YOU* USE IT?

Standard Reynocell panels with .024" stucco embossed aluminum facings are available in sizes up to 4′ x 16′ with thicknesses from 1" to 4" and with five types of edges. Modifications are possible subject to special inquiry. Reynolds engineers are already working with a number of manufacturers on applications of this amazing new product and are available to assist your designers. Write for more complete information and specifications. Reynolds Metals Company, 2560 So. Third Street, Louisville 1, Kentucky.

†T.M. registered

See "Mister Peepers" Sundays on NBC-TV. Consult local listing for time and station.

REYNOLDS ALUMINUM

MODERN DESIGN HAS ALUMINUM IN MIND

For more information, turn to Reader Service Card, Circle No. 458

New Engineering Materials

The units come as packages, with blowers or compressors mounted directly under the furnaces. All air, gas and electrical controls are mounted at the side of the housing.

Under ordinary use, according to the company, the two furnaces will function for at least eighteen months before rebricking is necessary, and supplied with the units is rebricking material and a set of formers so that rebricking can be done on the premises in a relatively short time.

Small Electron Microscope for Industrial Processing

A new Philips Electron Microscope (EM-75) at about half the cost and with about half the power of the large Philips unit (EM-100) is now available from the *Research & Control Instruments Div., North American Philips Co., Inc.*, 750 S. Fulton Ave., Mount Vernon, N. Y. Suitable for analytical work in industrial processing, research, medicine, pathology and biology, the new instrument utilizes an electron-optical system that includes condenser, objective and projector lenses.

Magnification is continuously adjustable between 1500 and 15,000 dia and resolving power is said to be better than 100 Angstroms under average operating conditions. The unit has a magnetic stabilizer for high voltage and lens currents, the electron gun is self-biased, and is equipped with an emission meter. The V-shaped filaments are easily replaced.

The electro-magnetic deflection method is used for beam alignment and focusing is facilitated by means of a beam wobbler. Specimen carriers for 1/8 in. dia grids and plates are available and a specimen airlock is utilized to obtain quick working cycles. Stereoscopic exposures can be made by tilting the specimen carrier 15 deg without breaking the vacuum. Diameter of the fluorescent screen is 4 3/8 in.; diameter of image 3 1/8 in., and a supplemental 2x optical magnifier is available that fits into place on the column. A camera using 35 mm standard film is employed on the microscope and each loading permits the making of rapid

New Engineering Materials

sequential exposures without breaking the vacuum.

The instrument has two pumps, one a rotary pre-vacuum unit and the other an oil diffusion unit. Vacuum obtainable is 10^{-4} mm of mercury and an ionization gage with neon tube is employed for measurement. A more exact determination is obtained by switching the emission microammeter over into the circuit of the gage.

The Philips EM-75 is approximately 74 in. high, 37 in. wide, and 25 in. deep. Power supply is 220 v, 50 or 60 cycles and power consumption is about 1 kw.

Portable Plater Uses Novel Agitation Unit

A "jet" agitation action eliminates mechanical agitation as well as motions which move the work in the new Jet Plater marketed by *Sel-Rex Precious Metals, Inc.*, 229 Main St., Belleville, N. J. The unit is said to also incorporate all the necessary equipment for mass production or small scale laboratory pilot plant plating of precious metals.

The standard Jet Plater models have 10, 20, or 30 gal capacity tanks and are designed for high speed plating with the Sel-Rex Bright Gold Process and Bright Silver Sol-U-Salt bath. The unit can be furnished with a rubber-lined or koreseal tank for use with acid solutions. According to the company, the unit can be used for still plating or can be fitted with a portable barrel for barrel plating operation.

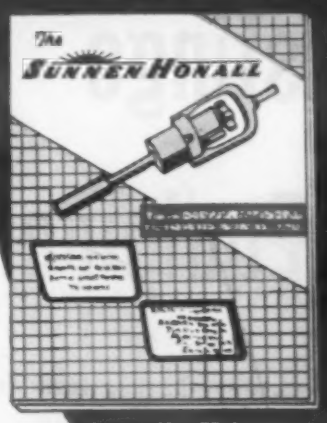
Automatic in operation, the unit consists of a Sel-Rex Selenium Rectifier with an automatic timer, of the proper output rating for the tank size; a stainless steel tank, which can be used as the anode, with a water compartment for temperature control; a movable work rack, which will accommodate a portable plating barrel; a stainless steel filter; a polyethylene, drip-proof pump powered with a ¼ hp motor; and a "safety" tank under the plating tank, pump and filter in case of leaks or accidental spilling.

As well as the standard size tanks, larger ones up to 100 gal can be built to specification.

No. 50 Sunnen Honing Machines

No. 51 Sunnen Portable Cylinder Hones

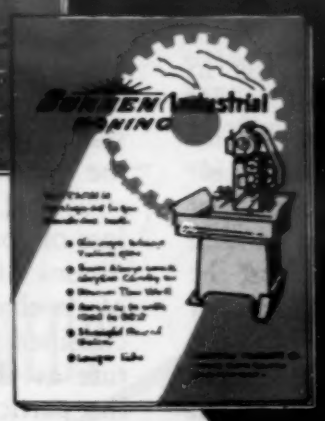
No. 505 Sunnen Honing Supplies & Accessories



No. 57 Sunnen Portable Honing

No. 55 Sunnen Tool Room Honing

No. 58 Sunnen External Hones



No. 60 Sunnen Honing Case Histories

These 7 FREE BOOKLETS Can Help You . . .

- ✓ Produce Accurate Internal Diameters
- ✓ Produce Accurate External Diameters
- ✓ Reduce Assembly Time
- ✓ Cut Production Costs on Internal Finishing
- ✓ Get Absolute Interchangeability of Parts with Precise Fits
- ✓ Get the Accuracy of Lapping in 1/5 the Time
- ✓ Eliminate Selective Fitting

SUNNEN® HONING Has Solved Such Problems For Hundreds of Other Companies . . . and may be the solution to some of your production headaches.

If your problem is how to meet newer, more exact specifications on bores and shafts, you'll want these booklets. They tell you how alert manufacturers are improving their products by honing . . . making them last longer and run smoother and cooler . . . making higher speeds permissible . . . all by using Sunnen Honing to produce smooth, accurate bushings and bores, as well as spindles, shafts, plungers and similar parts.

Use the coupon for your FREE booklets — no obligation.

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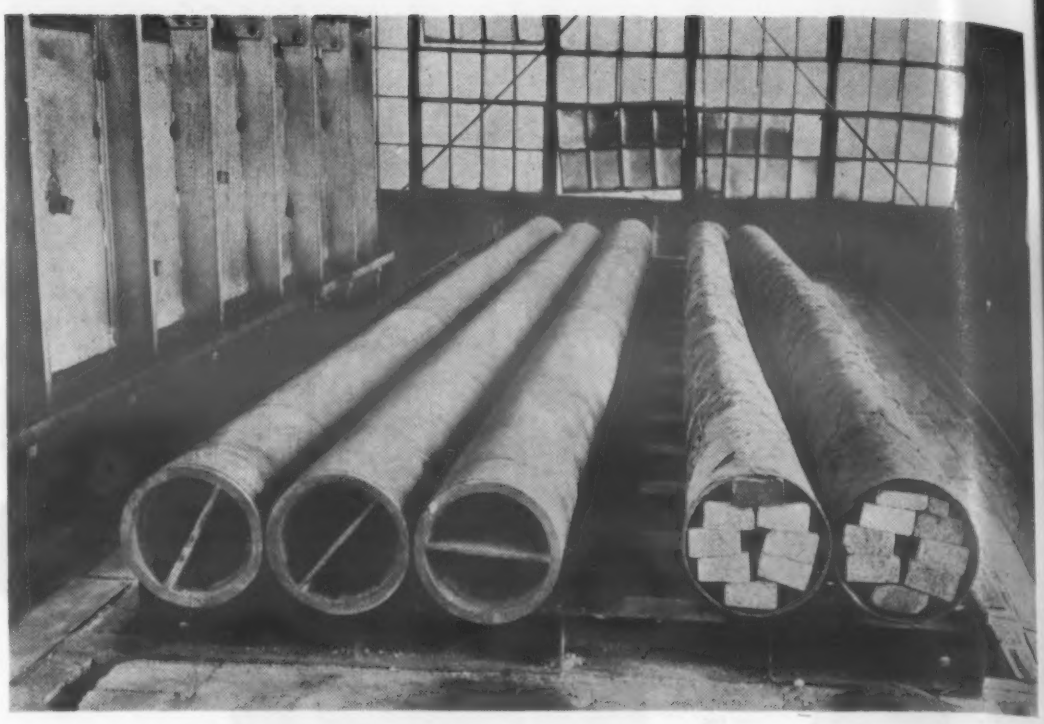


TYPE HH ALLOY annealing retorts (three on left) compared with carbon steel (two on right). Type HH was used for its higher strength and high resistance to sulfur-containing atmospheres. Note scaling, loss in section thickness and lack of symmetry in the carbon steel retorts.

High Alloy Castings in Heat Treating Equipment

by E. A. SCHOEFER, Executive Vice President, Alloy Casting Institute

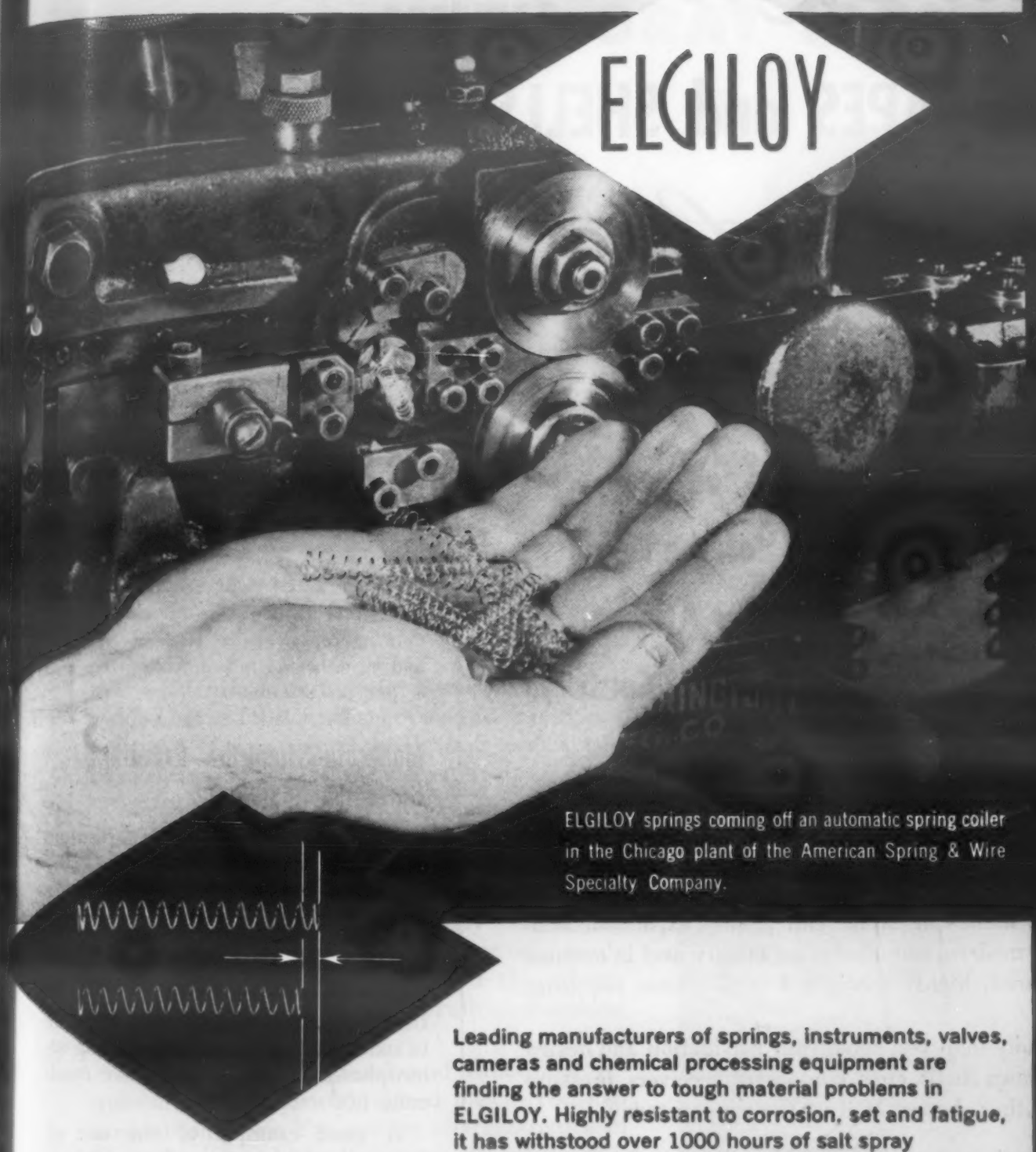
Choosing the proper alloy to meet particular service conditions can result in optimum life of heat treating equipment. Twelve cast alloy compositions have been classified by the Alloy Casting Institute as standard heat-resistant casting alloys and have been grouped as three distinct types.

● THE SELECTION OF materials in the construction of industrial equipment is complicated by the ever-increasing severity of the modern industrial processes. In the heat treating industry the metal to be used in equipment components must be carefully chosen to maintain proper strength under conditions of high temperature and the resulting hot gas corrosion. Each piece of equipment must operate under certain conditions and it is the job of the materials engineer to select the alloy which will give optimum service under each specific condition.

In continuous or intermittent service above 1200 F almost any atmosphere tends to be corrosive, and this hot gas corrosion causes progressive scaling which can eventually reduce the sectional area of an exposed structural element, with a consequent loss of load-carrying ability. For conditions of this type there is a group of twelve cast alloy compositions, classified by the Alloy Casting Institute as the "H" series, which have the particular properties necessary to meet these service requirements. These are the chromium-nickel-iron cast high alloys (containing more than 8% alloy content) which have, in turn, been broken down into three distinct types, each of which is suited to specific applications.

(Continued on page 196)

or springs that don't get tired!



ELGILOY springs coming off an automatic spring coiler in the Chicago plant of the American Spring & Wire Specialty Company.

Originally, these two springs were identical. After testing, the ELGILOY spring (top) took a set of less than 2% compared to approximately 10% for the music wire spring!

Leading manufacturers of springs, instruments, valves, cameras and chemical processing equipment are finding the answer to tough material problems in ELGILOY. Highly resistant to corrosion, set and fatigue, it has withstood over 1000 hours of salt spray exposure* without evidence of corrosion.

Available for general industrial use in flats and rounds, ELGILOY can be blanked, formed, soldered, brazed or welded. See how ELGILOY can meet your "severe service" requirements . . . write today for information on your application.

***Tests performed at 100% relative humidity, 20% salt spray at 95° F.**

MANY INDUSTRIES SOLVE "SEVERE SERVICE" PROBLEMS WITH ELGILOY

AIRCRAFT INSTRUMENTS
Calibrated springs of ELGILOY used because of ELGILOY'S resistance to set.

REFRIGERATORS
Springs are made of ELGILOY for longer life in locations exposed to corrosion problems.

CHEMICALS
Valve actuating springs of ELGILOY resist corrosive action of chemical materials.

ENGINES
Flapper valve resistance to fatigue under exposure to hot, corrosive exhaust gases is increased by ELGILOY.

MUNITIONS
Recoil spring for guns made of ELGILOY to absorb the repeated impact of recoil without fatigue or set.

SCALES
ELGILOY provides the strength and flexibility to make thin scale draft bands of lasting accuracy.

VALVES
In controlling the flow of chlorine and other chemicals, ELGILOY is used to protect against corrosion.

Tear out and mail for more facts on ELGILOY...

ELGILOY

ABRASIVES DIVISION

ELGIN NATIONAL WATCH COMPANY

ELGIN, ILLINOIS

Dept. C

Abrasives Division
Elgin National Watch Company
Elgin, Illinois

Send me additional information about ELGILOY—the alloy with outstanding resistance to corrosion, set and fatigue.

Name.....

Title.....

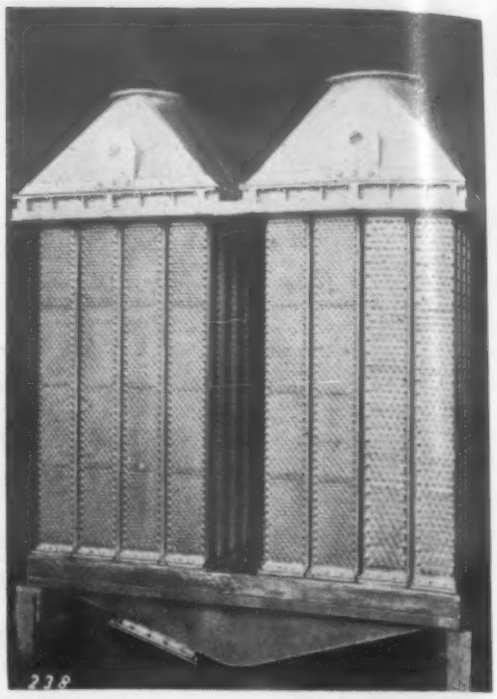
Company.....

Address.....

City.....Zone.....State.....

NOTE: Please describe the part for which you are considering the use of ELGILOY:.....

continued



TYPE HD ALLOY was selected for these recuperator castings for Thermal Transfer Corp. because of its moderate strength and its resistance to practically every type of hot gas corrosion.

Moderate Strength—Excellent Corrosion Resistance

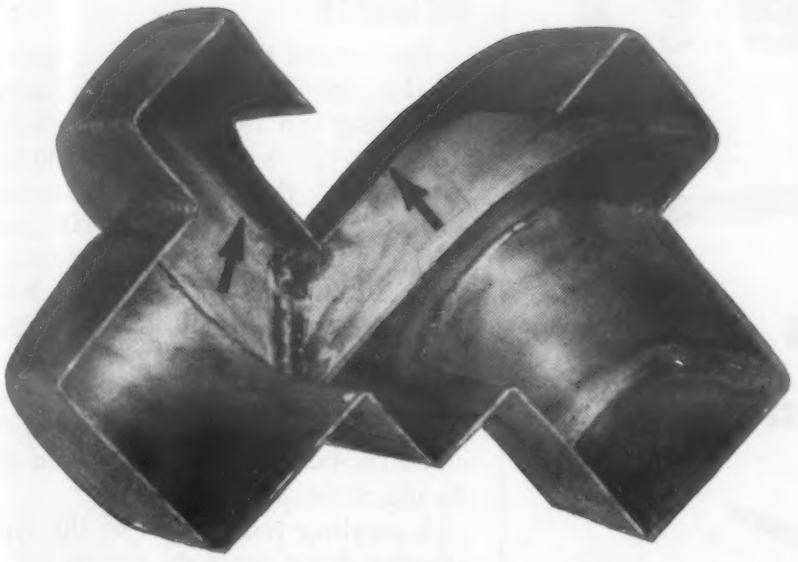
The first type is an iron-chromium alloy containing up to 30% chromium and under 7% nickel (Types HC and HD). Type HB alloy, containing only 18% chromium and useful only up to 1500 F is at times also included in this group. These ferritic alloys offer excellent resistance to oxidation and sulfur-containing atmospheres, although they have moderate hot strength.

A good example of the use of these alloys in heat treating applications is in the casting of recuperators, where properties of the alloys meet the requirement for resistance to hot gases while needing only moderate strength properties. The recuperators are usually installed in waste gas flues to recover the heat to be used for pre-heating air. In this particular application, strength requirements call for an alloy of somewhat better mechanical properties than Type HC, so Type HD is used. This alloy, containing 28% chromium and 5% nickel, can be used for applications where moderate stress is encountered up to 1400 F, and for somewhat lighter load-bearing duties up to 2000 F. Because of the high chromium content, Type HD resists oxidation and is especially useful in high sulfur-containing atmospheres.

(Continued on page 198)

Production costs cut 90%

WITH GRAY IRON



Gear cover fabricated from nine pieces. Arrows show cut-outs.

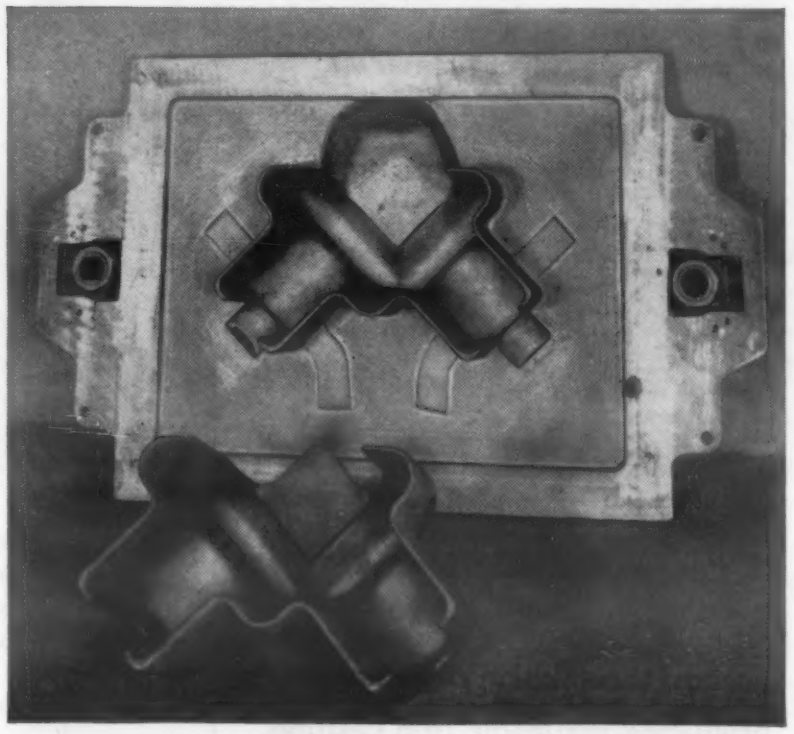
Made entirely in green sand, the Gray Iron castings were produced at one-tenth the cost of fabricated gear cover.

Formerly, nine separate pieces were shaped and welded into a fabricated gear cover for a braiding machine. Then, the manufacturer redesigned the gear cover for production in Gray Iron.

The finished and machined casting cost *less than 10%* of the production cost for the fabricated piece. This saving quickly paid for pattern-equipment costs . . . netting a *90% saving* on all parts thereafter. By redesigning for Gray Iron, the manufacturer not only made substantial savings, but obtained the advantages of a streamlined, vibration-absorbing gear cover.

Look at the structural and functional requirements of your fabricated parts. You can undoubtedly use the unique characteristics of Gray Iron—and the economy offered by this casting process. Why not write us for more information?

Matchplate and gear cover.



GRAY IRON CHARACTERISTICS INCLUDE:

Castability	Low Notch Sensitivity	Corrosion Resistance
Strength	Wear Resistance	Durability
Rigidity	Heat Resistance	Vibration Absorption
	Machinability	

MAKE IT *BETTER* WITH GRAY IRON

75% of all cast metal products are Gray Iron

GRAY IRON FOUNDERS' SOCIETY, INC.

NATIONAL CITY-E. 6th BLDG., CLEVELAND 14, OHIO

For more information, turn to Reader Service Card, Circle No. 327

continued

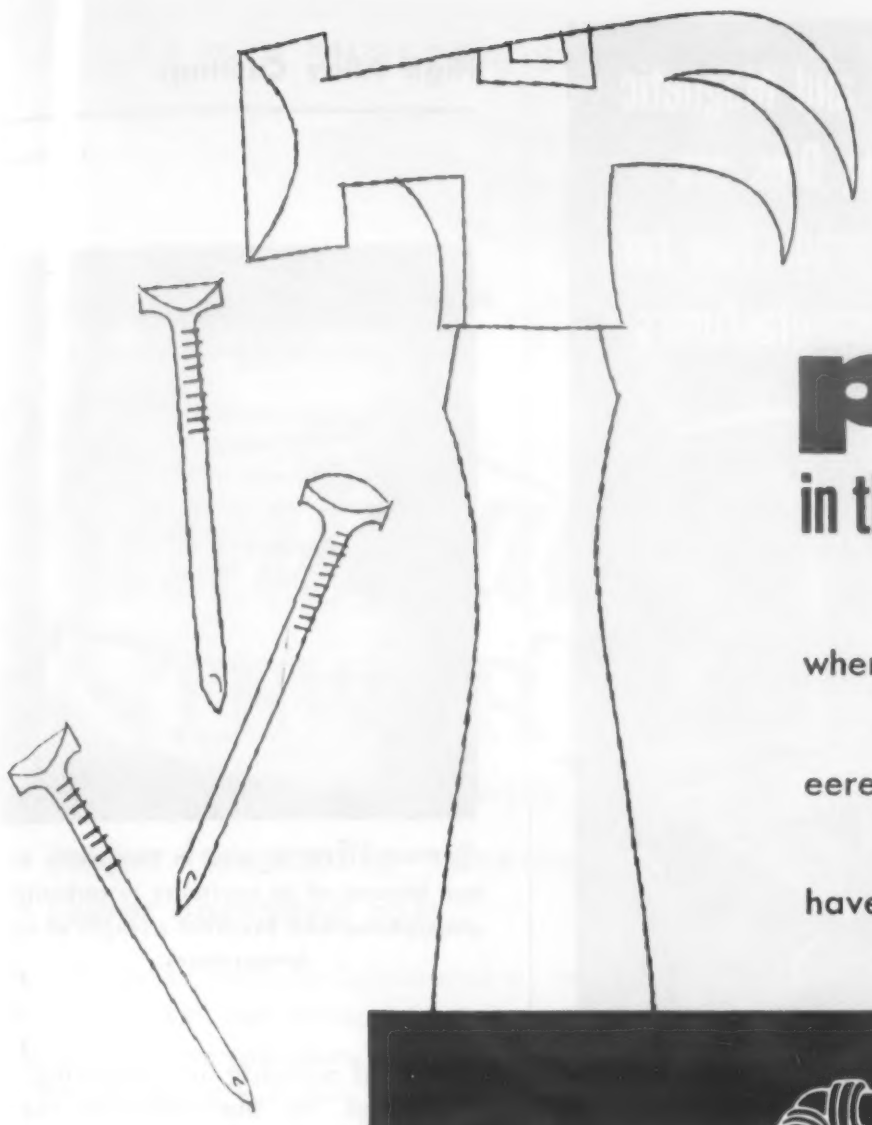
Good Strength—High Corrosion Resistance

The second type of alloy classified is the iron-chromium-nickel alloy containing 18 to 32% chromium, and 8 to 22% nickel, with higher chromium than nickel content (Types HE, HF, HH, HI, HK, and HL). Partially or fully austenitic, these alloys have greater high temperature strength and ductility than the straight iron-chromium group, will withstand greater loads and temperature cycles, and can be used in sulfur-bearing, oxidizing and reducing atmospheres.

Annealing retorts cast of this type of alloy have replaced retorts previously made of seamless carbon steel tubes. These retorts are used to protect high speed tool steel from combustion products in hood type furnaces heated by anthracite producer gas of high sulfur content. It was found that at the high temperatures used in the furnace, the HH alloy (24 to 28% chromium and 11 to 14% nickel) had the necessary high strength, ductility and corrosion resistance to give excellent service. With the seamless carbon steel pipes previously used, scaling, flattening, or deformation caused replacement after approximately 500 cycle hrs, or about 16 passes through the furnace. With the cast HH alloy, annealing retorts have now been installed for 3½ years and are reported to be still in good condition. Since the alloy resists the high sulfur content of furnace gases, there is little scaling, and the retorts have retained consistency of wall thickness, insuring uniform annealing of the load of tool steel. No loss of symmetry has been detected in the retorts, allowing maximum capacity loading of the furnaces. Bayonet plug ends, also cast of the same alloy remain gas-tight and easy to handle.

Excellent Strength—Moderate Corrosion Resistance

The third type of alloy is an iron-nickel-chromium analysis containing from 30 to 70% nickel and 10 to 20% chromium (Types HT, HU, HW, and HX). These alloys are fully austenitic, maintain excellent hot strength in applications up to 2100 F, and have good life under rapidly fluctuating temperatures. They



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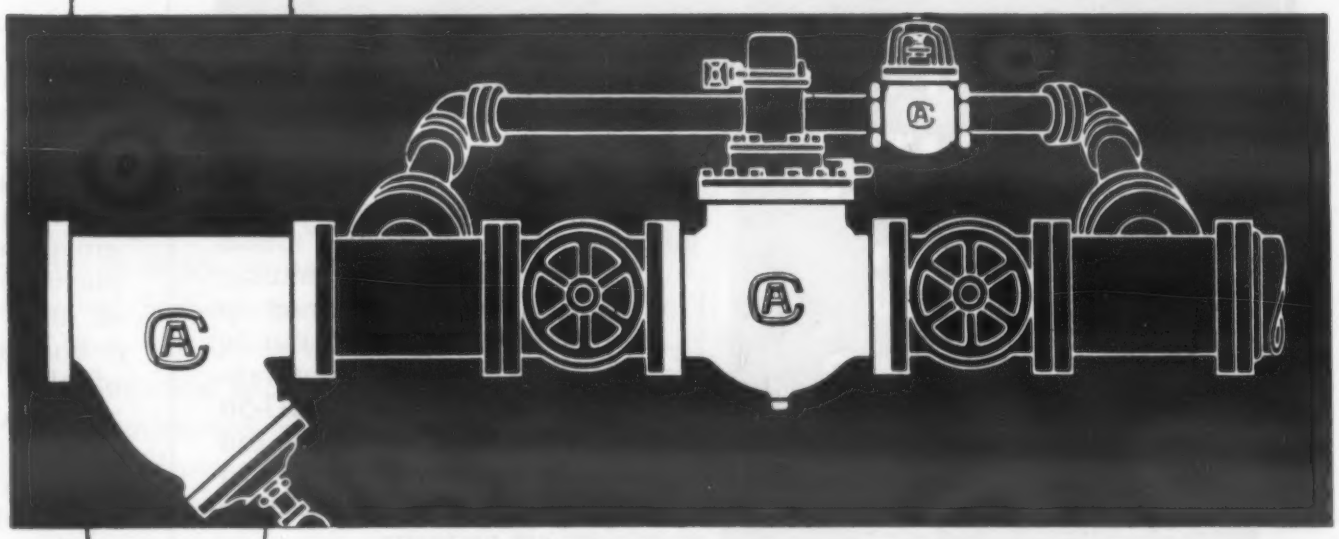
In every branch of the chemical process industries where the control of corrosive or abrasive fluids is a problem, it takes many types of specially engineered valves to do the job right. From the very beginning, Cooper Alloy design and foundry engineers have worked hand in hand with manufacturers of specialty valves to insure the production of stainless steel components that could be relied upon. If you design or manufacture control, safety, relief, or other special stainless steel valves, we invite you to share our know-how and experience. Write for your free copy of "Thirty Years of Progress", a booklet designed to give you a quick glimpse of our facilities.



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High Alloy Castings

continued

TYPE HT ALLOY is used in this muffle section because of its resistance to carburizing atmospheres and excellent strength at high temperatures.

withstand reducing and oxidizing atmospheres, do not carburize excessively, and do not take up nitrogen in a nitriding atmosphere. However, the high nickel content makes this group unsuitable for use in atmospheres containing substantial amounts of sulfur.

Due to these properties, this type of alloy is particularly suitable for applications in gas carburizing facilities as illustrated by muffle sections for modern mechanized furnaces. In high volume gas carburizing, the muffles usually function in a temperature range of 1650 to 1800 F, while the analysis of the gas used is approximately 33 to 35% hydrogen, 20% carbon monoxide, up to 7% ammonia, the balance being a carrier gas with about 40% nitrogen. Since under these conditions sulfur corrosion is not a problem, Type HT, containing 33 to 37% nickel and 13 to 17% chromium (including up to 1.25% silicon for increased resistance to carburization) was selected. As in all high nickel types, the alloy is fully austenitic and notable for excellent hot strength.

Since within each of these three classifications there are several alloys, each possessing slightly different properties, expert evaluation of service conditions is advisable. It is wise, therefore, to consult a metallurgist at one of the foundries specializing in high alloys, to be assured that the completed casting will have the characteristics necessary for optimum performance.

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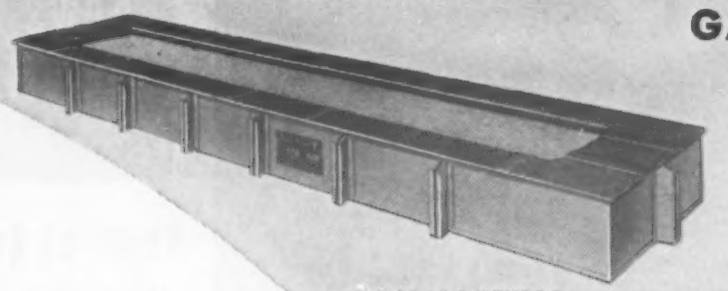

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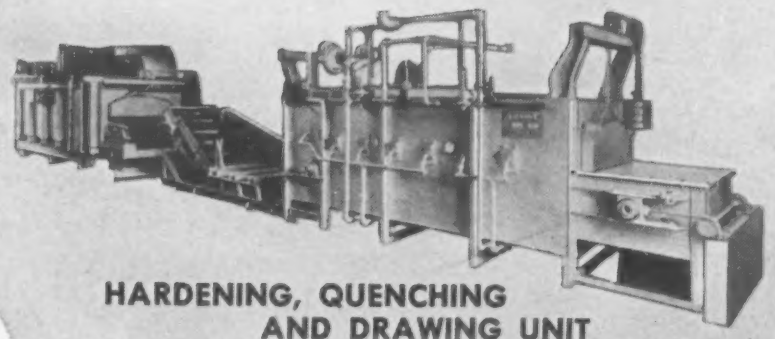
As a division of Sunbeam Corporation we have the opportunity of working with our furnaces in the production of Sunbeam appliances, lawn sprinklers, sheep shears, animal clippers, etc. In manufacturing our own products, we must contend with practically every heat treating problem faced by industry—a position unique in the furnace manufacturing field.

This experience with our own furnaces in large volume production enables us to render a service to you far beyond other manufacturers. That is one reason why Sunbeam Furnace installations have been so successful. They are based not only on furnace engineering ability, but on practical experience under actual operating conditions. We have learned through actual experience the factors that give longest furnace life . . . greatest production . . . best quality . . . and lowest operating cost.

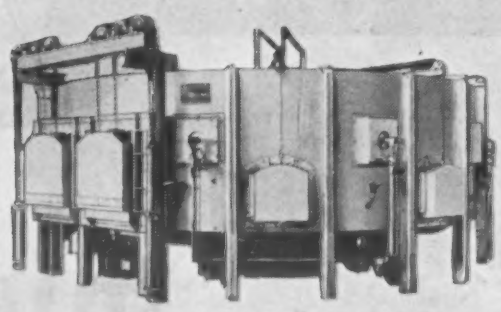
Our highly trained technical staff of furnace engineers who for over 50 years have built furnaces for the leading companies throughout the United States and abroad are qualified to recommend the correct type of furnace to meet your requirements.

Defense requirements can be met efficiently with proven Sunbeam heat treating equipment

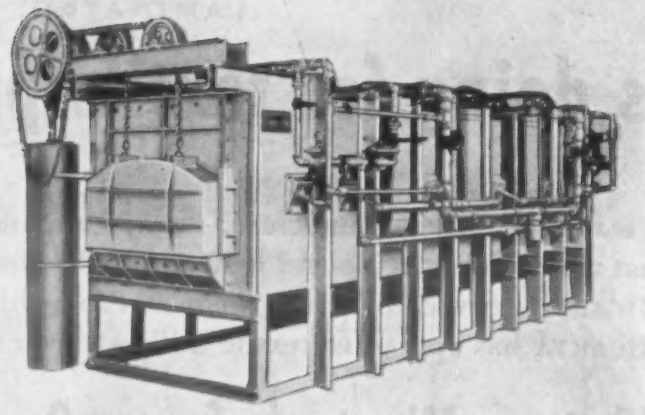
A letter, wire or 'phone call will promptly bring you information and details on Sunbeam Furnaces, either units for which plans are now ready or units especially designed to meet your needs. Or, if you prefer, a Sunbeam Stewart engineer will be glad to call and discuss your heat treating problem.



HARDENING, QUENCHING AND DRAWING UNIT

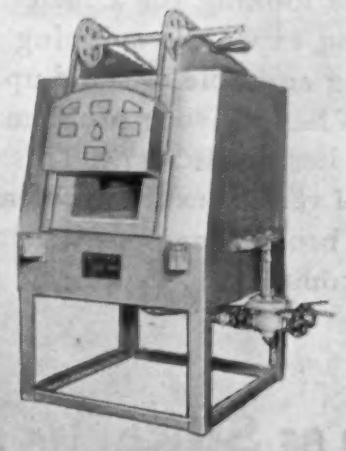


ROTARY HEARTH FORGE



PORTABLE OVEN FURNACE

RECIRCULATING FURNACES



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Canada Factory: 321 Weston Rd., So., Toronto 9

For more information, turn to Reader Service Card, Circle No. 481

news of ENGINEERS COMPANIES SOCIETIES

News of Engineers

L. F. Hickernell, chief engineer, Anaconda Wire & Cable Co., has been appointed chairman of the Technical Program Committee for the Winter General Meeting of the American Institute of Electrical Engineers.

Dr. George Gerard has been appointed assistant director, Research Div., New York University College of Engineering.

Thaddeus Augustyn has been named vice president, American Research Corp.

Dr. P. W. Bakarian has been named plant manager of Cramet Inc.

Dr. E. S. Towland, chief metallurgist, **Dr. O. J. Horger,** chief engineer, and **Dr. C. L. Clark,** research metallurgical engineer, Timken Roller Bearing Co., were recently awarded citations from the University of Michigan. The three men were among the 241 distinguished alumni of the University to be honored at a convocation in Ann Arbor.

L. Gerald Firth, internationally known pioneer and authority on specialty steels and sintered carbides, has retired as vice president and director of research for Firth Sterling, Inc. after 39 years of service with the company.

Thomas A. Norton, Jr. has been appointed supervisor of standards and **Richard A. Hassell,** standards engineer, Houdaille-Hershey Corp., North Chicago Div.

John E. Caskey has been elected a vice president of United States Rubber Co. and general manager of the company's Naugatuck Chemical Div. **George R. Vila,** will become assistant general manager.

Thomas D. Nast has been elected president of All-State Welding Alloys Co., Inc.

Frank A. Peschl has been appointed director of engineering, Olin Industries, Inc.

J. Stuart Franklin has been appointed supervisor of General Electric Co.'s Lighting and Rectifier Dept., Photometric Laboratory.

Isaac F. Kinnard, manager of engineering for General Electric Co.'s Meter and Instrument Dept., was awarded an honorary Doctor of Science degree during recent convocation ceremonies at Queen's University, Kingston, Ontario, Canada.

Dr. William D. Coolidge, former vice president and director of research for General Electric Co., was recently honored on his 80th birthday by more than 100 friends and associates at a reception and dinner at Nela Park. Dr. Coolidge is a world-famous scientist whose discoveries have given to society the modern lamp bulb, X-ray tube and other elec-

For more information, Circle No. 411

News of Engineers

tronic tubes, the art of powder metallurgy, and industrial cutting tools.

Robert L. Brownlee, manager of engineering administration, Carboloy Dept., General Electric Co., has been named plant manager of GE's Distribution Assemblies Dept. of the Industrial Power Components Div.

Frank B. Nuelle, a member of the engineering administration section at Carboloy Dept., General Electric Co., has been named manager of that section.

David J. Jay, formerly with the aircraft nuclear propulsion project of General Electric's Aircraft Gas Turbine Div., has joined the company's Carboloy Dept. as an engineer in the product and process development section.

Dr. Arthur G. Metcalfe, former metallurgist with the Deloro Smelting and Refining Co., Deloro, Ontario, has been named to hold the rank of full research metallurgist at Armour Research Foundation, Illinois Institute of Technology.

C. A. Windsor has been named manager of the Wire Equipment Div., Michigan Oven Co.

Ross B. Hopkins has been named plant metallurgist, Rodney Metals, Inc.

Raymond S. Perry has been elected president of the Federal Telephone and Radio Co. Mr. Perry succeeds **Henry C. Roemer,** who returns to the IT&T headquarters as vice president in charge of the administration of the Domestic Div. of IT&T.

E. R. Rowley has been named president of Titanium Metals Corp. of America, a subsidiary of National Lead Co. and Allegheny Ludlum Steel Corp.

Max Jaenchen has accepted the appointment as chief consulting engineer of Mannesmann-Meer Engineering and Construction Co.

Dr. George M. Anderson has been named head of the Engineering Development Group, Edison Laboratory.

Neal T. Williams has been assigned to the Edison Laboratory's physics research group.

John L. Ham has been named director of the Metallurgical Research Dept., National Research Corp. Mr. Ham assumes the position held by **James H. Moore** who became general manager of the company's wholly owned subsidiary, Vacuum Metals Corp.

Percy C. Shaffer, chief engineer, The Cooper Alloy Foundry Co., will take a six months leave of absence in order to assist the National Production Authority in the job of allocating nickel.

Robert G. Gustavson has joined the Pastushin Aviation Corp., Engineering Dept., as project engineer in charge of

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News of Engineers

jettisonable fuel tanks, external stores, and mechanism design.

Dr. James F. Eversole has been appointed vice president in charge of research, Bakelite Co.

Dr. Raymond W. McNamee has been made manager of research administration at Union Carbide and Carbon Corp. Dr. McNamee will help coordinate the research activities of all of the company laboratories where basic research and development is being done on alloys, chemicals, gases, carbons and plastics.

Kenneth S. Goodyear has been appointed to manage a newly organized Plastics Div., Boston Woven Hose & Rubber Co.

E. S. Chapman, formerly vice president and general manager, Clayton Manufacturing Co., has been elevated to the position of executive vice president in charge of all operations and **Perry Arant** has been appointed vice president in charge of engineering.

Max B. Mentley has been named vice president of manufacturing and **Ben F. Bregi,** vice president of engineering at National Broach & Machine Co.

Fred R. Bayne has been promoted to the position of chief engineer at Alten Foundry & Machine Works.

Victor A. Spoehr, vice president and general manager of The H. M. Harper Co., has been made director of the General Components Div., National Production Authority, U.S. Dept. of Commerce.

Cecil W. Humphreys has been appointed vice president in charge of manufacturing for Shell Chemical Corp.

Everett C. Schmactenberg has been appointed chief engineer of the Turbomachinery Engineering Services at Worthington Corp. Other appointments are: **C. J. Tullo** as chief engineer of the Centrifugal Engineering Div. and **Warren H. Fraser** and **William C. Krutzsch, Jr.** as assistant chief engineers of the Centrifugal Engineering Div.

W. W. Knight, Jr. has been appointed vice president, Barrett Div., Allied Chemical & Dye Corp.

Dr. Blaine O. Schoepfle, Leopold A. Robillard and **Dr. Samuel Gelfand** have joined the research and development staff of Hooker Electrochemical Co.

Dr. Otto Kardos has been appointed to the post of chief research electrochemist by Hanson-Van Winkle-Munning Co.

Dr. William E. Shoupp has been named assistant division manager in charge of development, Atomic Power Div., Westinghouse Electric Corp.

Gordon W. Johnson has joined the research and development staff, Alloy Engineering & Casting Co., as associate

Now...you can bond metal to wood with assembly-line speed

If you're laminating sheet metal or any other non-porous material to wood, take a careful look at this assembly line.

It shows how you can do your laminating job in less than 2 minutes. Using a recently developed Armstrong's Adhesive, this new process eliminates the need for overnight curing and heavy equipment.

The 60-foot laminating line shown here is typical. Alternate sheets of metal and plywood are sprayed with adhesive. Next, the adhesive film is dried in an infrared oven. A workman then assembles the laminates and guides them through a rubber-covered pinch roll. That's all. If you wish, you can work or ship the laminated pieces immediately.

No process could be more simple. There's no investment in jigs, clamps, or hydraulic presses. You eliminate the entire curing operation, too, saving both time and factory space.

The new adhesive has very good spraying properties, high dead-load strength, and great resistance to heat and water. It bonds stainless steel, fiberboard, aluminum, plywood, asbestos board, decorative laminates, and many other materials.

Armstrong has developed many ways of solving difficult bonding problems and reducing conventional laminating costs. For help on any laminating job, call or write Armstrong Cork Company, Industrial Adhesives Department, 8012 Dunbar Street, Lancaster, Pennsylvania. In Canada, Armstrong Cork Canada Ltd., 6961 Decarie Blvd., Montreal.

ARMSTRONG'S

ADHESIVES • COATINGS • SEALERS

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News of Engineers

project director on casting design process manual.

David I. Dilworth, Jr. has been appointed as director of metallurgy and **Lorin L. Ferall** as assistant vice president, Crucible Steel Co. of America.

Dr. O. G. Haywood, Jr. has been appointed manager of engineering planning, Sylvania Electric Products, Inc.

John E. Powers has been promoted to vice president, General Tire & Rubber Co.

Dwight H. Lory, former assistant to the general manager of the Norwood Plants of Allis-Chalmers Manufacturing Co., has been named assistant manager of the Texrope Drive Section.

D. T. O'Connor, chief of the Radiology Section, U.S. Naval Ordnance Laboratory, was awarded the first annual William D. Coolidge Award as the author of the outstanding paper of the year on X-ray. The award was made jointly by the Society for Non-Destructive Testing and the X-Ray Dept., General Electric Co. The paper, entitled, "Industrial Fluoroscopy" was published in the journal of the society and was presented at last year's session as the Mehl Lecture.

News of Societies

American Standards Association has announced that Ralph E. Flanders, senior Senator from Vermont, has received the nation's highest award in the field of standardization, the 1953 Howard Coonley Gold Medal for "service in advancing the national economy through voluntary standards". Colonel Perry L. Houser, general supervisor, manufacturing standards research, International Harvester Co., received the Standards Medal, which is awarded annually for leadership in the actual development and application of standards. The Association also announced that Dr. John Gaillard, mechanical engineer, staff of the ASA, and lecturer at Columbia University, will hold his next 5-day private seminar on industrial standardization from Jan. 25-29, 1954, in the Engineering Societies Bldg., 29 W. 39th St., New York, N.Y.

The American Society for Testing Materials has announced the appointment of Fred F. Van Atta, recently manager, Building Div., Carolinas Branch, Associated General Contractors, as special assistant on the headquarters staff.

The Association of Iron and Steel Engineers has announced the election of the following officers for 1954: president, Eric L. Anderson, superintendent of the Electrical Dept., Bethlehem Steel Co.; first vice president, John H. Vohr, general superintendent of U.S. Steel

(Continued on page 212)

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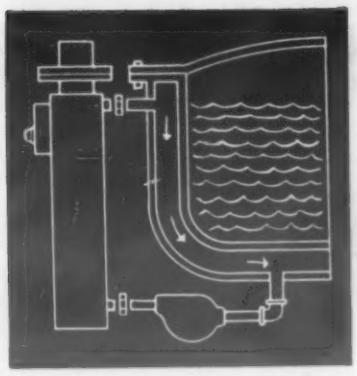
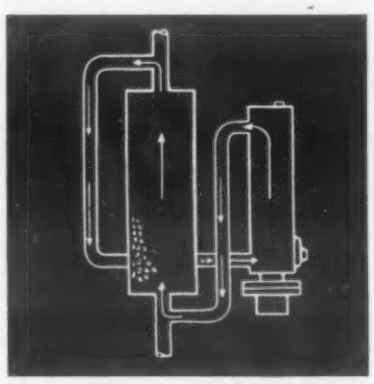
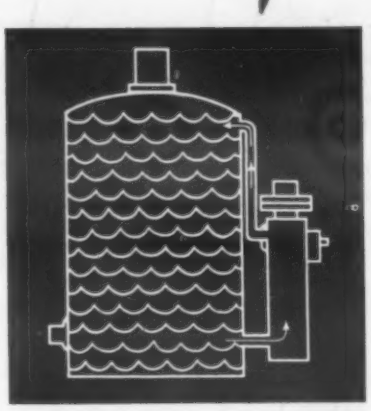


Circulation heater connected to jacketed process kettle.



Circulation heater as part of nitrogen heating assembly for reactivating alumina.



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News of Societies

Corp.; second vice president, W. H. Collison, assistant general superintendent, Blast Furnace Div., Great Lakes Steel Corp. At a recent meeting the board of directors of the Association voted to give Rose Polytechnic Institute the sum of $1500 which will be known as the Farrington-AISE Fund. This fund will be used by the school for scholarships or for needed equipment.

United Engineering Trustees, Inc. has announced the election of James L. Head, mining engineer, Anaconda Copper Mining Co., as president for 1954.

Atomic Industrial Forum, Inc. has announced the appointment of Charles E. Robbins, formerly vice president of Bozell & Jacobs, Inc., as executive manager. At the same time it was announced that Oliver Townsend, formerly the assistant to the chairman of the Atomic Energy Commission, was appointed assistant executive manager and secretary of the Forum.

The Foundry Equipment Manufacturers Association at its recent annual meeting elected the following officers: president, W. B. Wallis, president, Pittsburgh Lectromelt Furnace Corp.; vice president, D. E. Davidson, vice president sales, Link-Belt Co.

The Porcelain Enamel Institute at its annual meeting elected the following officers for the coming year: president, W. A. Barrows, Barrows Porcelain Enamel Co.; vice president, W. N. Noble, Ferro Corp.; J. E. Bourland, Texlite, Inc.; E. O. Brady, Briggs Manufacturing Co.; R. C. Myers, U.S. Steel Corp.; H. E. Patton, Ingram-Richardson Manufacturing Co.; and R. N. Smith, Temco, Inc.

Pressed Metal Institute elected Samuel P. Hull, vice president, Worcester Stamped Metal Co, as president for the coming year. Elected as vice president of the Institute was James M. Leake, president, Leake Stamping Co. Appointed as technical director in charge of the Institute's new technical and engineering department was R. W. Breckenridge, formerly president, Automatic Die and Products Co., and more recently a director of PMI.

Armour Research Foundation, Illinois Institute of Technology, has announced the establishment of eleven cooperative scholarships for work in metallurigcal and mechanical engineering.

The American Welding Society has re-elected as its president for 1953-54, Fred L. Plummer director of engineering, Hammond Iron Works. Other officers elected for the coming year are: J. H. Humberstone, vice president, Air Reduction Co., Inc., as first vice president and J. J. Chyle, director of welding research, A. O. Smith Corp., as second vice president.

The Society has also announced the thirteen winners of the 1953 Resistance Welder Manufacturers Association Prize

News of Societies

Contest. First prize of $750.00 for the paper entitled "Design and Application of Edge Ring Welding" was awarded to Chester A. Czohara, Manufacturing Research Dept., International Harvester Co.. The $500 second prize was awarded for the paper, "Balancing Inverse Parallel Connected Ignitrons in Frequency Converter Spot Welders Using Cathode Ray Oscilloscope", authored by Glenn C. Woodmancy, an engineer with Boeing Airplane Co. The $250 third prize went to a paper entitled "Spotwelding of Magnesium with Three Phase Low Frequency Equipment" authored by three men: Paul Klain, research metallurgist, Dow Chemical Co.; Paul Thorne, chief electrical engineer, and Dean L. Knight, chief welding engineer, National Electric Welding Machines Co.

The Society has named Walter H. Wooding, superintendent Metals Section, Industrial Test Laboratory, Philadelphia Naval Shipyard, Philadelphia Naval Base, as recipient of the 1953 Lincoln Gold Medal Award for his paper entitled "The Inert-Gas-Shielded Metal-Arc Welding Process".

American Society for Metals has announced the following officers for the coming year: president, J. B. Austin, director, Research Laboratories, U.S. Steel Corp.; vice president, George A. Roberts, chief metallurgist, Vanadium Alloys Steel Corp.

Society for Non-Destructive Testing has announced the election of Gerold H. Tenney, Los Alamos Scientific Laboratories, as president and William C. Hitt, Douglas Aircraft Co., Inc., as vice president.

News of Companies

The Wesson Co. and **Wesson Metal Corp.** have announced the creation of a new Experimental Research and Product Development Div. **William Bader,** vice-president, will head the new department.

Westinghouse Electric Corp. has announced the formation of a new engineering section in its atomic equipment department to be responsible for a development, design and test program involving certain equipment for nuclear power plants. **Edward J. Kreh** will manage the new section to be known as the Equipment Development Section.

Dolan Steel Co., Inc. has constructed a $50,000 addition to its plant at Bridgeport, Conn.

Pennsylvania Peerless Corp. has announced completion of its new Pottsville, Penna., plant. The new plant is already working at peak capacity.

General Electric Co.'s Trumbull Electric Dept. has been expanded into two

News of Companies

new departments, the Distribution Assemblies Dept. and the Trumbull Components Dept.

James H. Knapp Co. has moved into its new plant at 1731 Workman St., Los Angeles 31.

Lindberg Steel Treating Co. has moved to its new heat treating plant at 1981 N. Ruby St., Melrose Park, Ill.

Peter A. Frasse and Co., Inc. recently held opening ceremonies at a new office and warehouse on Locust St., Hartford, Conn. The new operation will be devoted to the distribution of alloy, stainless and cold finished carbon steels, as well as alloy and stainless tubing in the Connecticut and New England area.

General Electric Co. plans to construct a $1.8 million combustion laboratory in Schenectady to aid scientists in obtaining knowledge needed to produce more powerful gas turbines for aircraft and other applications.

Scovill Manufacturing Co. has opened a new $500,000 warehousing and shipping center to serve its manufacturing center. The facilities are located near the middle of its main plant in Waterbury, Conn.

Knapp Mills, Inc. has announced the formation of **Knapp Mills de Mexico, S.A.,** with headquarters in Mexico City.

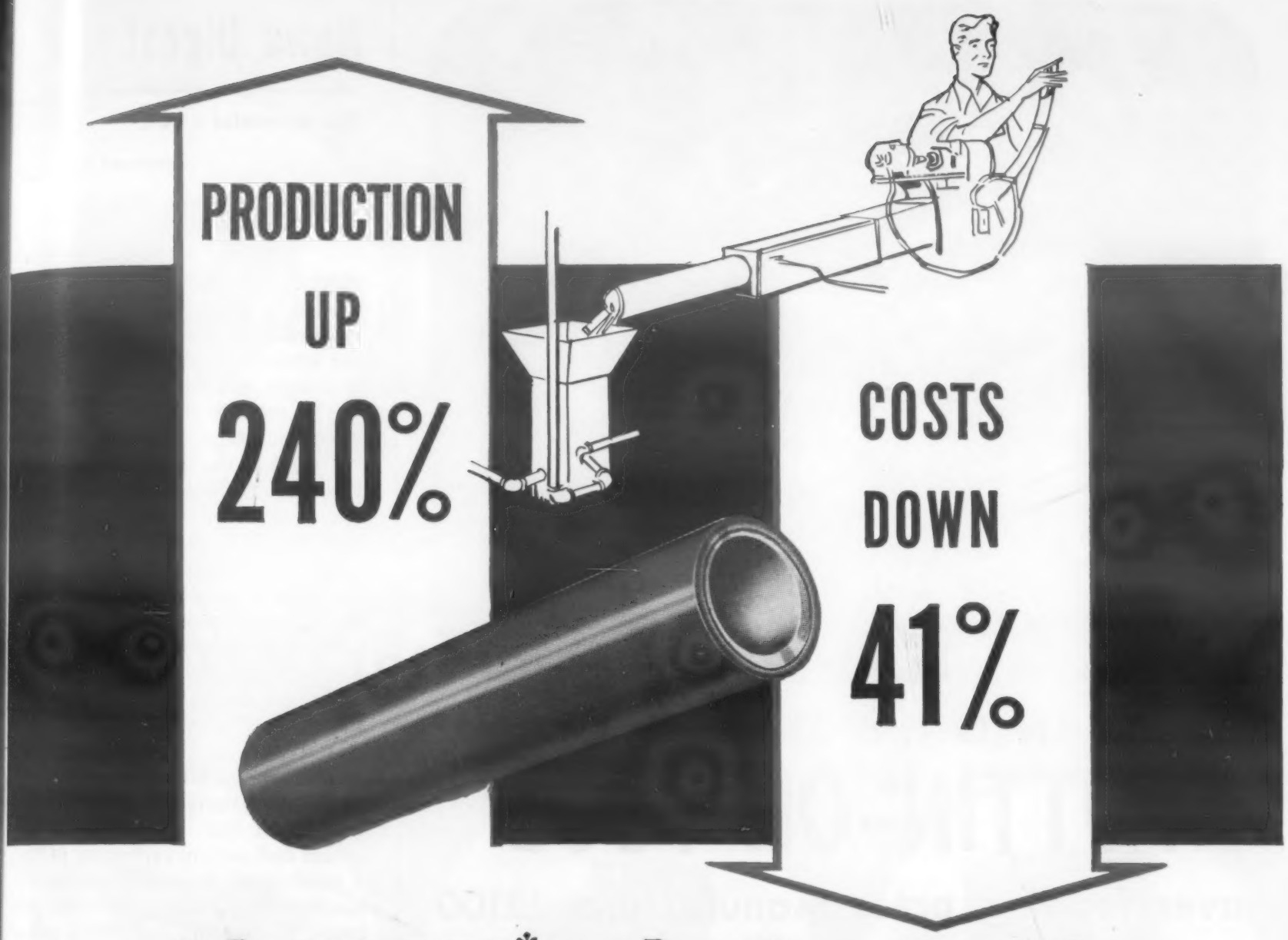
Fiberite Corp. has acquired complete formulations and procedural data for the manufacture of medium-high-impact and high-impact plastic materials formerly produced at the Bound Brook, N.J. plant of **Bakelite Co.**

Colorado Fuel and Iron Corp. officially opened its new $30 million seamless tube mill at Pueblo, Colo.

Yale & Towne Manufacturing Co. has established a new division, The Powdered Metal Products Div., consolidating the company's expanding operations in the field of metal powders. The new division unifies under one management, the recently acquired **Powdered Metal Products Corp. of America,** and the **American Sintered Alloys Div.** George L. Bachner, formerly president of PMPCA, has been appointed general manager of the new division.

Consolidated Industries, Inc. has announced the completion of a new die shop designed to help meet the aircraft industry's demand for aluminum, titanium, and alloy steel forgings.

The Sheffield Corp. will henceforth design, manufacture and market Cavitron machine tools, according to a joint announcement by the **Cavitron Corp.** The agreement provides that the Cavitron Corp. will continue to produce the ultrasonic transducers and generators, being the originators of the ultrasonic machining process and holders of the basic patent rights, and will issue licenses for the process through Sheffield.



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Whether you're interested in upping production or downing costs—or both—it pays to investigate TOCCO Induction Heating if you heat-treat, anneal, braze, solder, forge or melt ferrous or non-ferrous metal parts.

PRODUCTION UP—When Thompson Products Ltd., St. Catharines, Ontario switched from conventional methods to TOCCO Induction Hardening of their automotive wrist pins, production rose from 500 to 1200 per hour.

COSTS DOWN—While production jumped, costs fell from $5.46 per hundred parts to $3.23—a savings of more than 2c per pin or $26.76 per hour on the hardening operation alone.

OTHER ADVANTAGES— Additional savings result from elimination of hauling wrist pins to and from the heat-treat department. Cool, clean TOCCO fits right in the production line, next to related operations—takes only ¼ the space of the pusher-type furnace previously used.

In Canada or the United States TOCCO engineers are glad to survey your operations for similar cost-cutting results—no obligation, of course.

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Please send copy of "Typical Results of TOCCO Induction Hardening and Heat Treating".

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News Digest

Modutronics . . . .

continued from page

ployed steal the show, the develop ment and design of the basic module is actually the most important part of the project. It is completely unique in design and use of materials.

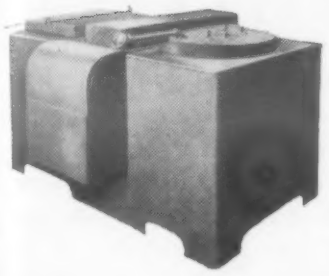
The module selected was a single electronic stage. Roughly speaking it included the resistors, capacitors and circuitry required for a single vacuum tube or transistor. The actual modular unit consists of six ceramic wafers on which circuit components are printed or baked. The wafers are stacked and twelve riser wires are soldered to notches in the edges. The twelve wires provide physical support and serve as electrical connectors. A tube socket is mounted on the top wafer.

The ceramic wafers are made from basic raw materials at the start of the production line. A mixture of talc, kaolin and barium carbonate provides a ceramic of desireable moisture resistance, strength and dielectric properties. The ceramic material is pressed into thin wafers on an automatic press and baked in a line kiln. The notches to receive the riser wires are painted with silver paint, and the wafers are routed to machines that apply resistors or capacitors to one or both sides. A single wafer can take one capacitor, or up to four resistors, providing total power dissipation is kept within ¼ watt.

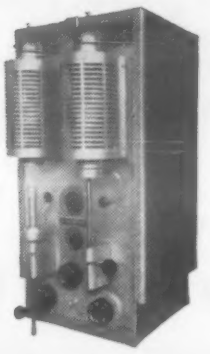
Maximum capacity of the printed capacitor wafer is about 0.03 microfarads and ranges down to 7 micro microfarads. "Commerical" accuracy standards have been attained, but quality control is still somewhat of a problem. Resistors are carbon impregnated asbestos Quinterra tape applied between silver-paint printed contacts on the wafer. Polyethelene tape is baked on over the resistor tape to give it protection. A 75 ft roll of tape will produce over 10,000 resistors ranging from 10 ohms to 10,000 ohms, and the resistors so produced will hold their rated resistance within 10% at operating temperatures up to 200 F.

After the proper circuit components have been applied to the wafers, they are tested in punch card programmed testing machines, and then put through the final assembly unit which solders the riser wires to the silvered notches in the sides of the

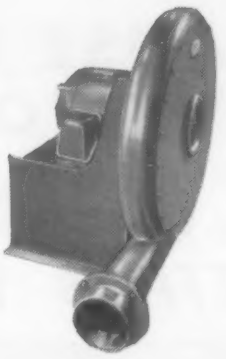
..melting furnaces



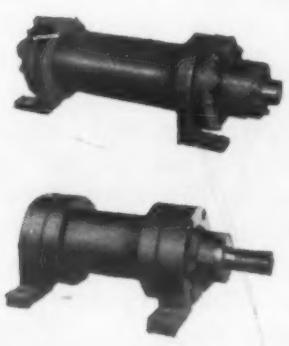
..laboratory equipment



..blowers



Heat Treating Furnaces . . . Yes!
and LINDBERG also builds . .



..hydraulic cylinders
..air cylinders

..transformers

..high frequency induction units

In addition to heat treating furnaces, Lindberg designs and builds a broad and varied line of related products . . from air cylinders to high frequency induction units.

The story of the complete line of Lindberg products is told in a newly published bulletin. Ask your local Lindberg Man for a copy (#250), or write Lindberg Engineering Company, 2450 West Hubbard St., Chicago, Illinois

LINDBERG FURNACES

News Digest

wafers—36 joints are soldered simultaneously—two soldering operations are required. After the risers are soldered, the wires are automatically clipped at points between the wafers in order to provide the correct circuit for the module. A final card programmed testing machine tests all completed modules. The finished modules can be inserted automatically to printed-circuit bases and dip-soldered to produce a complete electronic component.

The production rate goal of the pilot plant is 1000 modules per hr, which is roughly equivalent to 1000 six tube table-radio circuits per 8 hr working day. Considering that very little labor would be needed in a commercial application of the system, 24 hr application is economical.

National Bureau of Standards engineers on the project admit that the present system will take a lot of modification and further development before it is commercially sound. Materials for and methods of producing precision resistors and capacitors need perfecting, and some bugs must be worked out of the production equipment. However, the scientists point to the fact that electronic components now being produced by the system actually operate just as well or better than conventional equipment in performance tests. They point out that the present system is totally mechanized—to the point, in some cases, where it may well be uneconomical. A detailed cost study is underway at present and is expected to be complete about the first of the year. NBS men believe that in many cases hand assembly of the modular components would be less costly than present mass production of standard electronic circuits. They are planning to supply modular components for experimental hand assembly sometime in December in order to familiarize industry with the system.

The pilot plant is open for inspection one day a week at Arlington Va. Visiting arrangements should be made through local Naval Security Officers. Information and drawings are available to industry from the U. S. Navy Bureau of Aeronautics code reference IP43.

(More News on page 224)

○ *Hydraulic Cylinders by* Mullins *Koldflo** Process *are* *less expensive* *and* *better*...

because

NO Machining!

NO Grinding!

NO Honing!

NO Welding!

NO Heat Treating!

NO Alloy Steels!

ROUNDNESS to within 0.001"

STRAIGHTNESS to within 0.002"

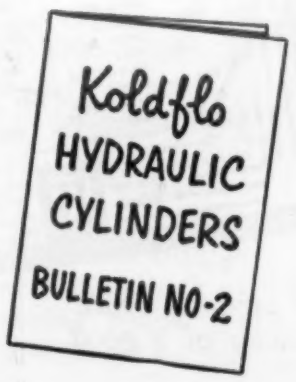
CONCENTRICITY to within 0.005" total

SMOOTHNESS—no "O"-ring wear

Koldflo Cylinders have NO TAPER and are made up to 42" long . . . and with integral bottoms

Hydraulic cylinders are made by the Mullins Steel KOLDFLO* Process in *one piece,* coming from the presses with smoothness, hardness, strength and precision never before achieved.

This process eliminates costly 3-piece construction and substantially cuts production costs.



In addition, hydraulic accumulators made by the KOLDFLO Process lose less pressure in performance tests. Less pressure is lost because of the better "O"-ring seal characteristics of the surface of hydraulic accumulators produced by this method.

If you're tired of 3-piece tubing and casting cylinders; if you want a round, straight hole with no taper; if you want BETTER CYLINDERS, write for your copy, Hydraulic Cylinders, Bulletin No. 2, today.

Koldflo Division
MULLINS MANUFACTURING CORPORATION
SALEM, OHIO

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News Digest

Tariffs . . .

continued from page 8

materials to the world's largest importer. The switch has come about through sheer necessity. With the tremendous growth in manufacturing potential, our industrial appetite has outgrown the production capacity of domestic sources of raw materials. In some cases, such as the Mesabi Range, seemingly inexhaustible raw material deposits have been used up. In order to maintain and increase our production levels we have been forced to import on a vast scale.

The position of the United States was recently spelled out very clearly, as far as strategic materials are concerned, when studies revealed that the only two metals that can supply our present consumption from sources within our borders are molybdenum and magnesium. Out of a list of 74 "strategic" materials, we must import all our supply of more than forty, and, with the above exceptions, at least part of the supply of all the rest. Since the only prospect for cutting down raw material imports is a drastic reduction in production, it would appear that the necessity of importing raw materials will exert a strong and constantly growing influence for easing trade barriers. However, opposition to this trend is still very much alive. On November 3, the National Lead and Zinc Committee applied to the Tariff Commission for an increase in levys on foreign imports on the ground that low priced foreign imports were forcing American mines to close.

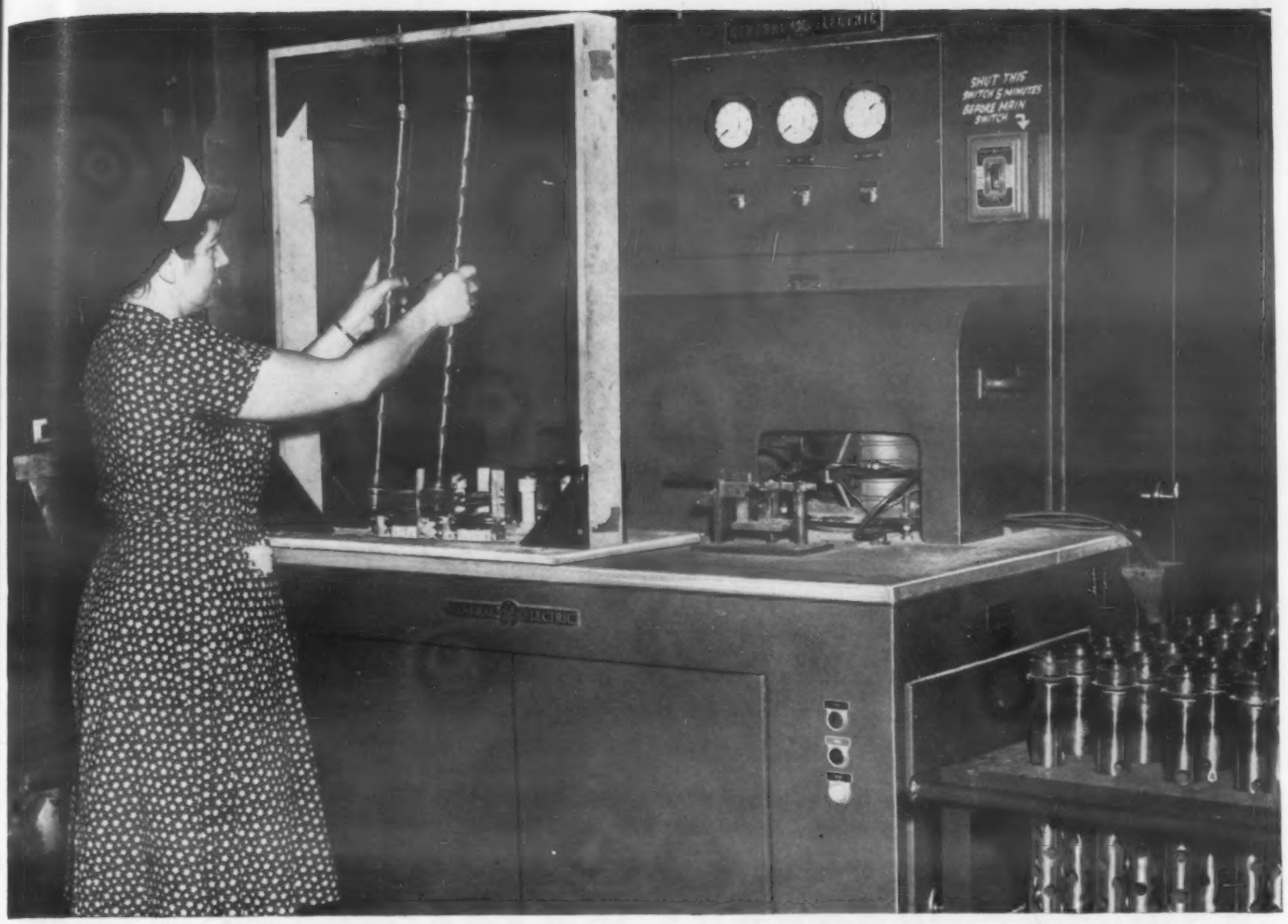
The U. S. Tariff Commission hearings under the Reciprocal Trade Act are another good indication of the general climate of opinion in industry and government. Under the act, domestic manufacturers of products on which tariff concessions have been arranged may apply for relief from the low duty rates if foreign competition causes or threatens to cause material harm to domestic business. Of the thirty cases that have gone before the tariff commission, nearly every one has been turned down by the Commission or the President of the United States. President Eisenhower, in rejecting the recommendation of the Tariff Commission for increasing the duty on silk scarves from Japan, indicated he would pass no tariff increases until the report of a

News Digest

special Commission on Foreign Economic Policy is completed.

The Commission on Foreign Economic Policy, now holding national hearings, is still another important sounding board that gives an indication of the attitude of the Administration, Congress and private business. President Eisenhower has let it be known that the recommendations of the special Commission will play a large part in his own approach to the tariff question. Chances are, if the Commission works out a program with which all members are in substantial agreement, it will have an excellent chance for passage in Congress. Among the Commission's Congressional representatives are the chairmen of the House Ways and Means Committee and the Senate Finance Committee, both of whom are generally considered to be of "protectionist" bent. President Eisenhower is known to favor low barriers to foreign trade and he appointed Clarence Randall of Inland Steel as Chairman of the Committee in the hope that Randall's influence could effect a compromise between the free traders and the protectionists. At present it does not look like any compromise will be arrived at by the committee, since it is rapidly dividing into two camps. The majority report, supported by Randall, will undoubtedly plug for gradual reductions in tariffs, while a minority report will recommend increases in tariffs on many items. If the conflicting reports result in a bitter floor fight in Congress, the outcome may well be little more than another extension of the present Reciprocal Trade Act with some concessions to special interest groups in order to get the bill through.

Groups testifying before the Randall Commission show some significant switches from the traditional lineup. Free trade and protectionist sentiments seem to cross party lines, political philosophies and labor-management boundaries. It boils down, roughly, to the fact that those in healthy industries, be they labor or management, are for free trade, while those in "sick" or depressed industries want more protection. Steel, automobile, and processed food manufacturers want across the board easing of trade barriers, while producers of lead, zinc, coal, some farm and dairy



COMPACT G-E HEATERS FOR BRAZING FIT PERFECTLY INTO NEW STRAIGHT-LINE PRODUCTION SETUP AT THE SACO-LOWELL CO.

Rejects Eliminated in Gun-jacket Assembly

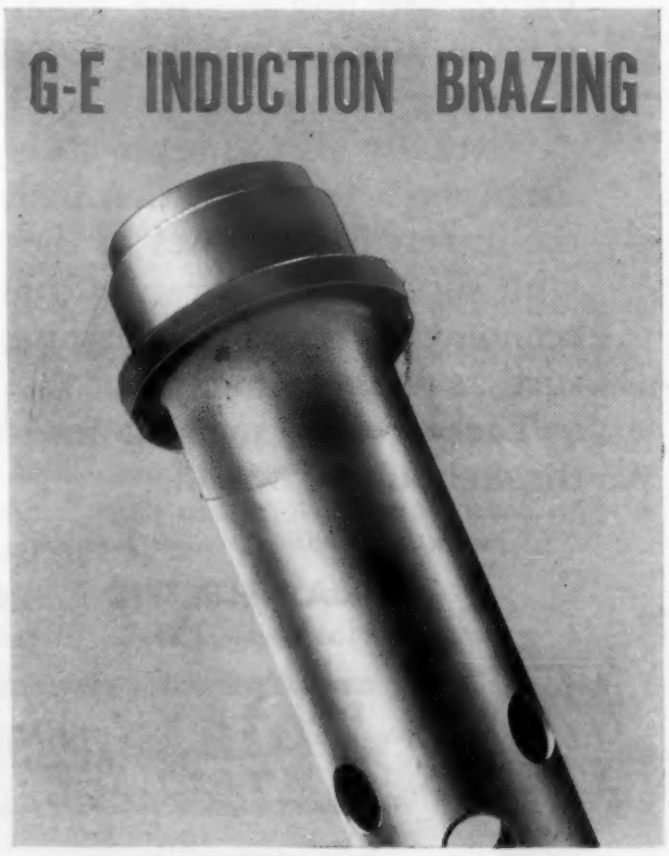
Saco-Lowell Company speeds production, cuts costs with G-E Induction Heaters

"In planning our machine-gun production program, we find G-E induction heaters assure us the high-quality brazing necessary to meet strict Ordnance Department requirements," says F. A. Skinner, Chief Engineer, Edwards Plant, Saco-Lowell Shops, Biddeford, Maine.

At Saco-Lowell, brazing rejects are a thing of the past. Only spot checks are necessary for product inspection, because G-E heaters provide a strong, uniform braze time after time. Saco-Lowell saves on operator training too, because use of these semi-automatic G-E heaters is mastered easily in a few hours.

To learn how you can profitably apply induction heat to your metal processing—in brazing, forging, hardening, or annealing—contact your nearest G-E Apparatus Sales representative today. And write now for new, modern-metal-processing bulletin GEA-5889 on furnace and induction brazing to General Electric Company, Section 720-122, Schenectady 5, N. Y.

GENERAL ELECTRIC



SELECTIVE HEAT produces this clean, strong bond of bearing breach to barrel jacket. Sixty such joints are brazed per hour.

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News Digest

products, oil, and some skilled crafts want more protection. The split in attitude is apparent from the following summaries of representative testimony:

George Meany of the AF of L sent a statement that in his estimation, completely abolishing tariffs would displace less than 300,000 workers, and that a comprehensive tariff revision spread over years would increase imports significantly while displacing between 60,000 and 90,000 workers—less than the numbers of workers usually displaced by technological change.

The "Committee of Industry, Agriculture and Labor on Import Export Policy," which is a national group representing organizations such as the United Mine Workers, textile producers, fruit ranchers, and others who are getting rough competition from foreign imports passed a resolution calling for the removal of Randall, who they charged, was aligned with forces who favor an increase in foreign competition and whose designs, if carried out, would result in the failure of hundreds of businesses and would throw thousands and thousands of wage earners out of work.

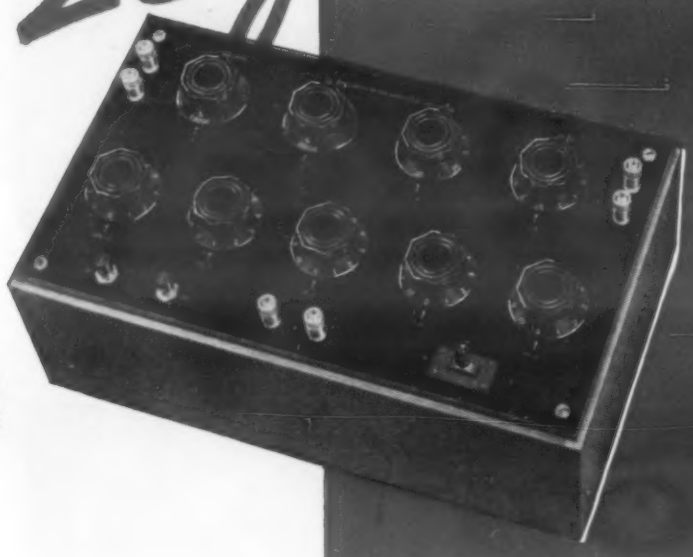
Meyer Kestenbaum, speaking for the Committee for Economic Development, a private group, claimed that the area of possible hardship from tariff reduction is small. Pointing out that most U.S. imports were raw materials essential for production, he showed that imports of finished goods last year represented only 0.3% of total consumption of manufactured goods. Along with many of those who testified, Kestenbaum claimed that labor and business dislocation from a gradual reduction in trade barriers would be less than that expected from ordinary domestic causes.

Alan B. Kline, of the National Farm Bureau, recommended that no special protective categories should be set up for any items. He deplored the fact that farm exports have declined and placed the blame largely on trade restrictions both in the U. S. and abroad.

Representative Simpson of the House Ways and Means Committee and the Randall Commission charged that "certain business leaders are engaged in a fantastic campaign for unrestricted imports" that would, in

(Continued on page 230)

"We have used D-H MANGANIN for 25 years..."



DOUBLE-PURPOSE BRIDGE. This Shallcross Model 6320 Wheatstone Limit Bridge can be used both for exact resistance readings and, in production, for rapid checks on percent deviation from an accepted standard. Overall range extends from 0.1 ohms to 111,110,000 ohms. All resistors are D-H Manganin.

Says **SHALLCROSS MANUFACTURING COMPANY,** Collingdale, Pa.: "For 25 years we have been using Driver-Harris Manganin* wire in the construction of Wheatstone and other precision bridges. In addition, D-H Manganin alloy has been used in many special standards for research and development laboratories. We feel that the quality of our products and the reputation of our instruments have been greatly enhanced by its use."

Behind statements like these stand Driver-Harris production and drawing techniques, which provide Manganin of such fixed stability that maximum change in resistance between 15°C and 35°C is only about 15 parts per million per degree centigrade—and frequently *less than one-third this* amount. Equally good electrical characteristics are available for ammeter shunt stock operating between 40°C and 60°C.

The experience of Shallcross reflects the experience of a host of manufacturers throughout the country; reflects what *you* can expect from Driver-Harris products, whether Manganin or any of the numerous alloys developed by Driver-Harris for application in the electrical and electronic fields.

Whatever your alloy problem, therefore, let us have your specifications. We'll gladly put at your disposal the skills acquired from 50 years of alloy manufacturing experience . . . make recommendations based on your specific needs.

*Sole producers of world-famous Nichrome**

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco

In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario.

MAKERS OF THE MOST COMPLETE LINE OF ELECTRIC HEATING, RESISTANCE, AND ELECTRONIC ALLOYS IN THE WORLD

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News Digest

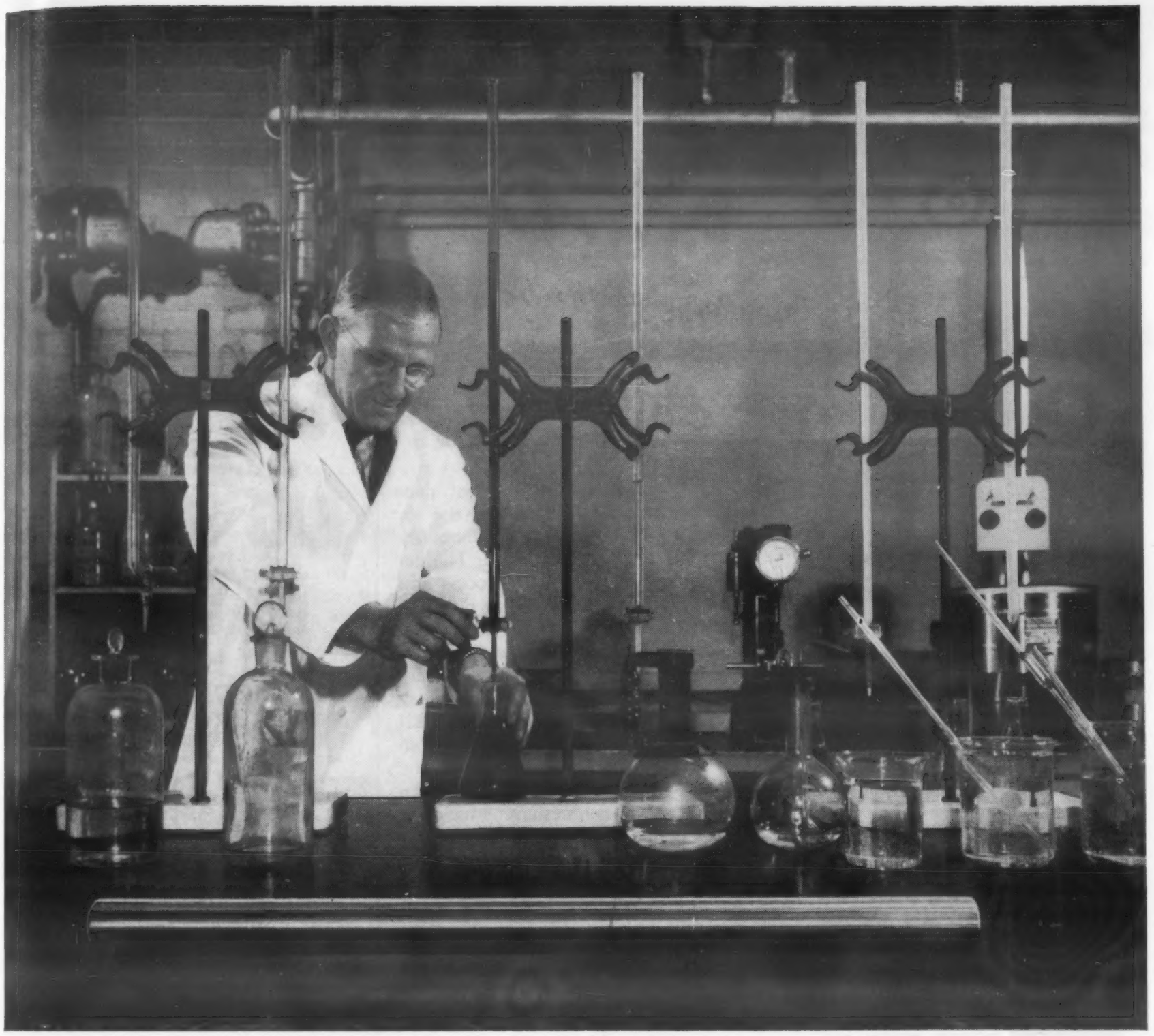
effect "import a major business depression".

It is very hard to arrive at anything that could be called a consensus of opinion on tariffs, since consensus implies at least some agreement, but it may be said that the majority of testimony heard so far has been for some degree of gradual tariff reduction as a long range goal. But between the two opposing camps there is little agreement even within industries. For instance, while one group of manufacturers of watch movements was testifying before the Tariff Commission in an effort to have tariffs on Swiss watches increased, another major American watch manufacturer went on record that their domestic production not only was not endangered, but that the company benefited by the low prices of Swiss movements that it bought and used in some of its own lines of watches.

Solomon Fabricant, Acting Director of Research of the National Bureau, recently pointed out during a round table discussion of the tariff, "After all this worry, after decades of thought, we have today no really very clear idea of what happens if tariffs are reduced." He underscored the need for more actual facts in selecting solutions of the foreign trade problem. One thing very clear to many hard good materials users today, is that the U. S. is no longer self sufficient as far as raw materials are concerned. It will be one of the few incontestable facts placed before Congress in the next session.

Civilian Zirconium Production Boosted

A line of new vacuum melting furnaces will start pouring zirconium ingots for industrial use early in 1954. Privately financed by the Firth Sterling Corp., the facility will operate as a civilian unit and will not be under the control of government contract. The company is now putting finishing touches on an installation at Trafford, Pa. which will turn out 360,000 lb of zirconium ingots per year from Kroll process sponge. Firth's



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Columbia alloy bars have muscle—and plenty of it. It's the kind of uniform strength that our many customers have learned to rely on, because each alloy bar is made to the same exacting standards as the last.

Only specially selected raw material is used. This material is subjected to a continous series of tests (like the one shown above) to verify its exact metallurgical content. What's more, each step of our production is rigorously Quality-Controlled by our laboratory to produce alloy bars that you can use in *your production* with minimum treatment and waste. ● More product information —technical assistance, too—are yours for the asking. Call or write today.

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McKeesport tool-steel plant will get expanded zirconium rolling capacity and will convert a major portion of ingot output into billets, bars, rods, strips, sheets, wire and tubing for industrial use. The material will be available to the Atomic Energy Commission for structural applications involving nuclear reactors, if needed, but production is primarily planned to supplement government needs and to supply the latent demand for zirconium in civilian industry.

Until recently, zirconium of ductile purity was produced by the iodide process and was a laboratory curiosity at $300 per pound. The development of the Kroll process and the heavy demand for ultra pure zirconium for atomic projects have reduced the price of commercial zirconium sponge to about $10 per pound.

The great demand for the metal on the part of the AEC stems from its low neutron absorption rate. The only comparable metals are beryllium, bismuth and magnesium, which are not suitable for structural use in reactors for a variety of reasons. Zirconium is not only the best material for use in reactors, but is just about the only material that is at all practical for such use. The presence of of very small amounts of hafnium, a metal that is chemically similar to zirconium and is always found in conjunction with it as an impurity, vastly increases the neutron absorption of zirconium. The average hafnium impurity does not alter the physical characteristics of zirconium as far as most non-atomic uses are concerned, and since the process of separating the two metals is expensive, commercial zirconium always contains between 2 and 3% hafnium.

Present applications of commercial zirconium are largely based on the metal's excellent corrosion resistance. Zirconium is in a class with tantalum and the precious metals resistance to hydrochloric acid and is much more economical on a pound for pound basis. It is an excellent candidate as a material for heat transfer units involving hydrochloric acid. The metal is highly resistant to nitric acid in all concentrations and makes a good storage material for fuming nitric. Rockets using nitric acid as a fuel component are a possible application. Zirconium is resistant to dilute sulfuric acid and its alkali resistance is

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At no extra cost, you enlist the services of an extra guardian when you have your die castings made by one of the listed die casters, licensed CZ producers.

Under the **Certified Zinc Alloy Plan,** your die castings are subject to periodic, searching scientific scrutiny to make certain that they are *on grade,* that the alloy meets the specifications *you* set.

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News Digest

comparable to that of silver and nickel.

Until relatively recently, very little work has been done on zirconium alloys for non-nuclear use, but with an increasing supply of the metal and possible lower cost, zirconium may be expected to take a place as a complement to titanium in applications demanding strength and corrosion resistance.

Zirconium prices from the new Firth Sterling Corp. facilities have not been announced, but current market prices for finished zirconium stock range from about $27 lb for hot rolled sheet to $35 per lb for cold rolled.

U. S. Navy Sponsors Tube Reducing Plant

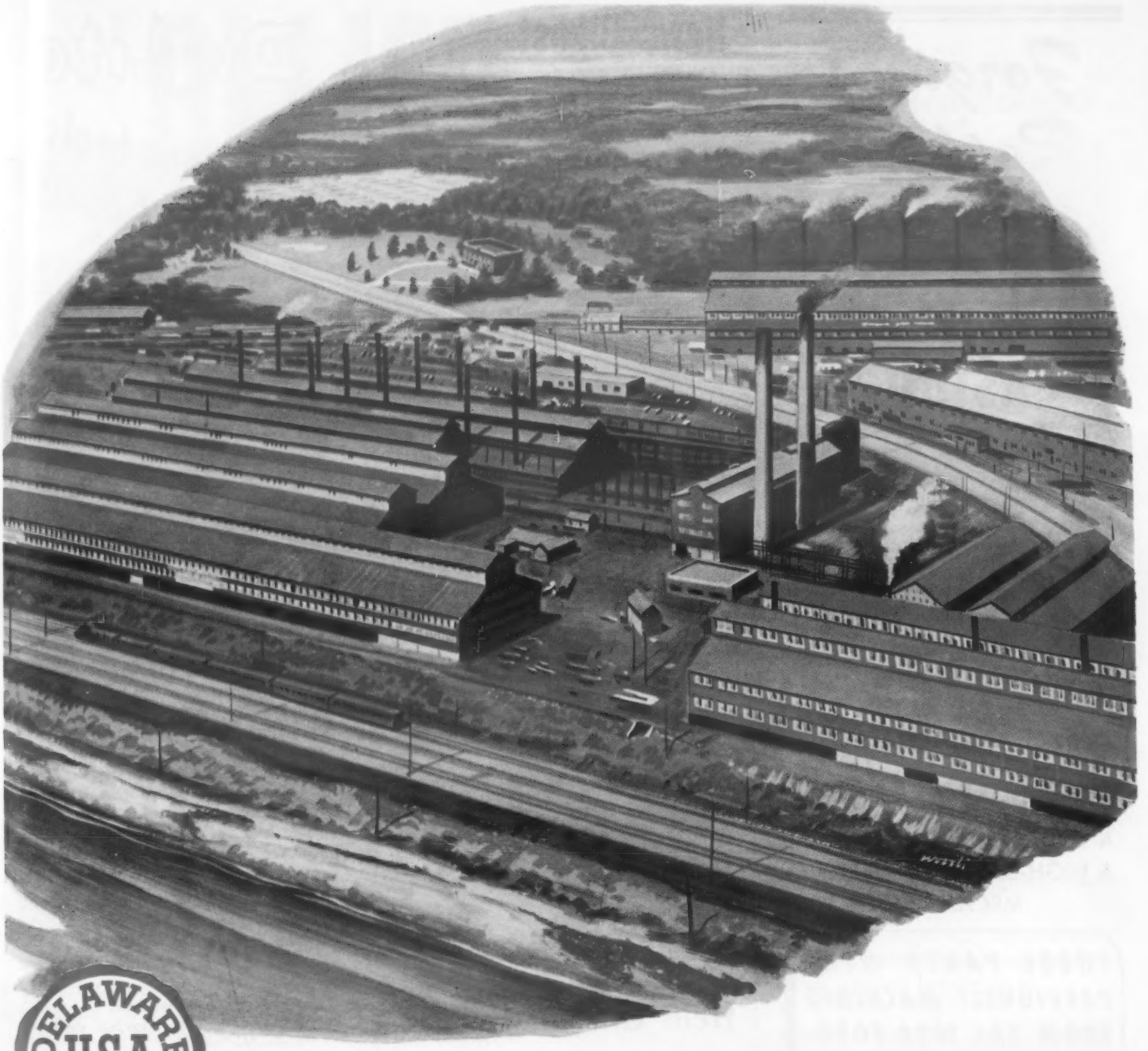
A new tube reducing plant with two of the largest tube reducers ever designed will go into operation in early 1954. The Navy Bureau of Aeronautics is sponsoring the new facility, which will be operated by the Tube Reducing Corp.

The new plant will produce tubing primarily for use in military items, although civilian consumption of its products will be encouraged in keeping with the Navy's dual industrial procurement program.

The Navy is building the plant at a cost of over $10 million. The plant has facilities for making special purpose dies, and includes standard size equipment in addition to the new giant tube reducers which will handle tubing from 6 to 18 in. in outer diameter.

The plant will produce cold compression formed tubing for use in military items such as large propeller cores, landing gear braces and struts, helicopter spars and rocket and Jato bodies. The tubing will also be available for commercial use in such applications as aircraft parts, large sized hydraulic cylinders, accumulators, casings and ring shaped products that require high strength thin-wall precision tubing.

Tubing fabricated by compression forming has higher tensile strength, closer tolerances, and better surface finish, advantages which help reduce



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These include Alloy and Carbon Steel Plates . . . Stainless-Clad Plates . . . Flanged and Dished Heads . . . Manhole Fittings and Covers . . . and Large Diameter Welded Steel Pipe for transmission of oil, gas or water.

In our Claymont plant all of these products are under complete quality control starting with the making of steel in our own open hearth furnaces and continuing through every step of manufacture.

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CLAYMONT, DELAWARE
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News Digest

fabrication costs. The new reducer will produce cold finished tubing in sizes heretofore unavailable, and the development of many new applications is expected.

Both the standard size and new large size reducers will process tubing of a variety of metals, including carbon and alloy steels, aluminum, copper and brass, stainless steel, and titanium.

Standard size tube reducers now in operation at the Tube Reducing Corp. finish tubing from 7/8 in. to 6 1/2 in. in outer diameter. The largest of the two new reducers will process ingoing tubing from 10 to 18 in. in outer diameter for reduction to 9 to 17 in. The other large reducer will bridge the gap between the standard machines and the largest reducer, handling tubing from 6 to 10 in. in dia. The new reducers will produce tubing with wall thicknesses as thin as 0.125 in.

Plastic Parts Standards Held Unrealistic

"More realistic" standards for plastic molded parts were urged at a recent meeting of the Society of Plastics Engineers. According to J. P. Healey, President of the Buffalo SPE, many standards now imposed on plastic parts are merely carryovers from previous metallurgical criteria and do not meet present needs.

Healey claimed that the yardsticks now applied to such plastic parts as nylon gears are arbitrary and do not give sufficient weight to the performance characteristics of the material. He charged that important advances in plastic part production efficiency are being retarded by an insistance on the application of rigidly precise metal item standards that have no practical significance when applied to plastic parts.

Nylon gears were singled out as a prime example of parts subject to incorrect standards requirements. The inherent qualities of nylon permit gears made from the material to op-

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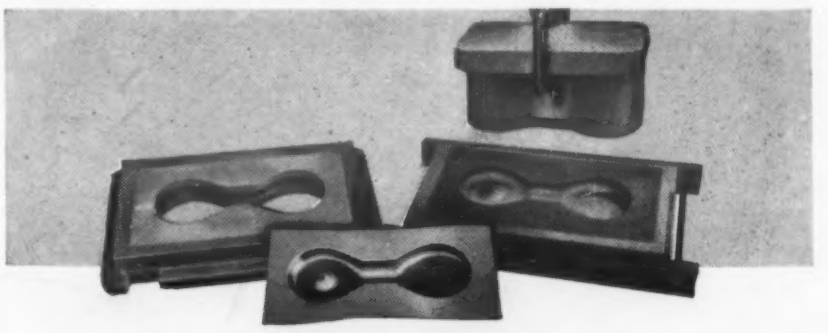

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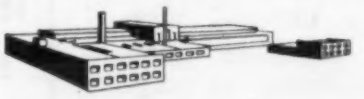
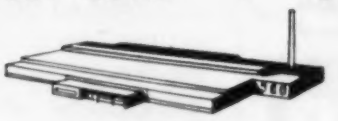


PLANT 2
Detroit, Mich.



PLANT 3
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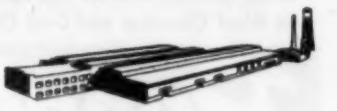

PLANT 4
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News Digest

erate noiselessly without lubrication and still outlast their lubricated metal equivalents. However, when excessively rigid standards are applied to nylon gears, they cannot be produced by the most economical beryllium-copper casting methods.

Healey admitted that the beryllium copper molding process involves a variation in shape due to shrinkage in both the mold material and in the plastic itself, but claimed that the shrinkage factor is predictable and can be compensated for in original design. Even when nylon gears do not meet the exact specifications set for metal gears, the superior wear characteristics of nylon may be expected to outperform metal that meets the most exacting specifications. Healey contended that engineers tend to forget the additional leeway that is permissible when they object to a minor difference in clearance that shows up when the involute of the plastic gears is checked against a pattern set by metal ones.

Because plastic parts produced by beryllium copper casting cost "pennies" compared to "dollars" for machined metal equivalents, Healey urged that an operational frame of reference should be substituted for abstract standards.

New Substitute For Stainless

Metallurgists at Battelle Memorial Institute have developed a new iron base alloy as the result of a search for a substitute for stainless steel used in the reinforcing braid of lightweight cable. The new alloy is expected to be useful in many applications requiring a material with moderate corrosion resistance, good workability, and resistance to magnetization.

The new alloy substitutes manganese and copper for all of the nickel

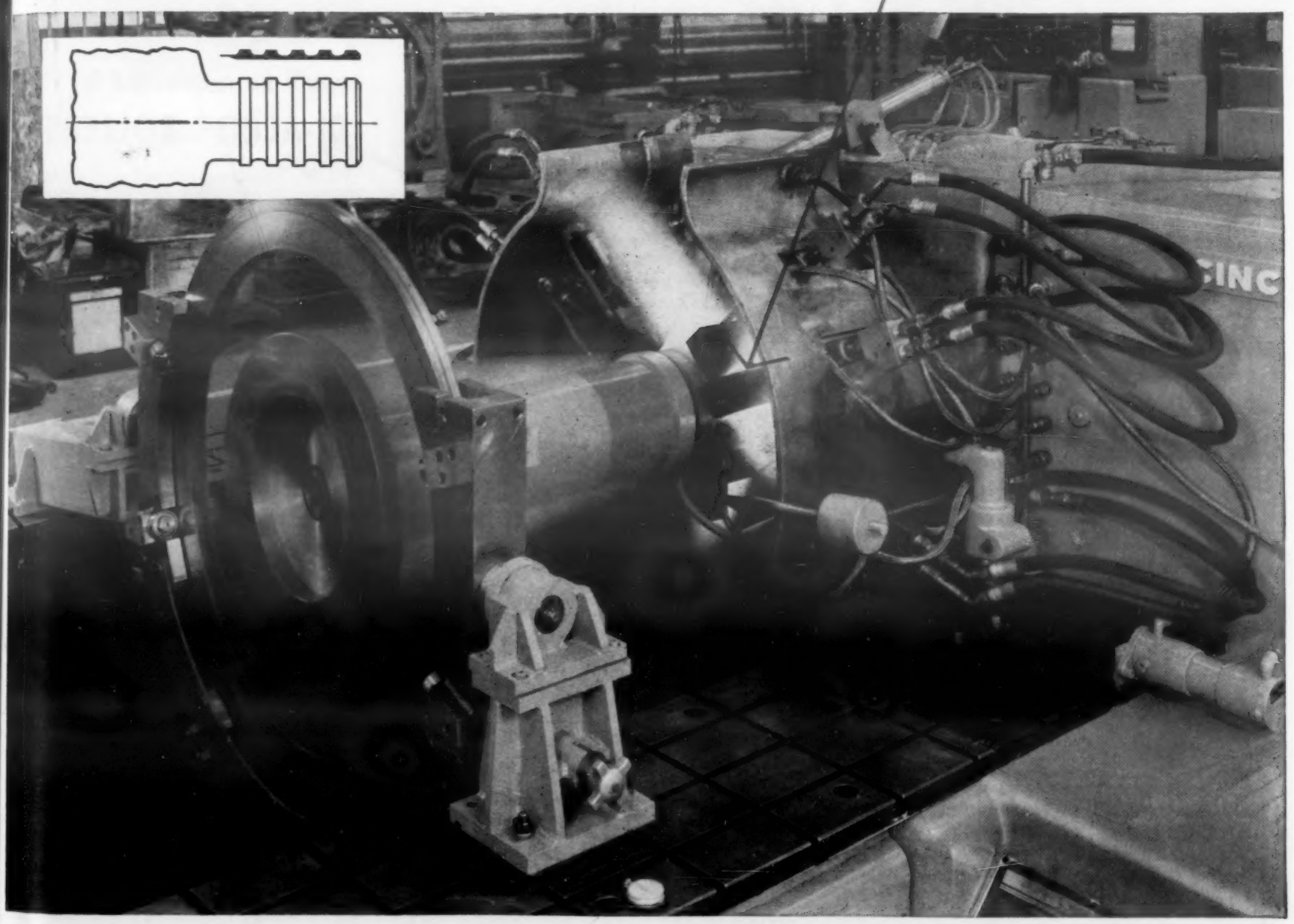
what's new in flamatic selective surface hardening

yesterday

It's a far cry from the working model of the early Cincinnati Flamatic hardening machine shown at left to the "do-the-impossible" machines being run off today in the Flamatic Heat Engineering Laboratory. While the early machine hardened small gears in actual production and (among other things) helped to break a critical bottleneck in production of automatic 90 mm. gun loaders . . .

today

. . . one of Cincinnati's latest Flamatics (below) is hardening ball retention raceways in the assemblies for mounting propeller blades to go on aircraft we can't talk about. Races must be surface hardened to rigid specifications, before bearings are installed in the large assemblies. The work holding fixture by itself is quite a masterpiece. While Flamatics are getting bigger and more versatile, the original principles still apply: concentrate heat, control temperatures and confine hardness.



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and much of the chromium used in the original wire material.

Previously, stainless steel was the only commercial material that met the requirements of Signal Corps Specifications for a reinforcing braid wire in cables known as the "Spiral four" type. Since cable of this type is encased in a protective cover, the superior corrosion resistance of nickel chromium steel is not required, and Battelle metallurgists were asked to develop a substitute for conservation purposes.

H. O. McIntyre and George Manning, the men who developed the new alloy, stated that further development work is desirable. However, their work so far has shown that the properties defined for the new material can be expected from alloys within the following percentage ranges: Carbon, 0.08 to 0.15%; Chromium, 9.0 to 11.0%; Manganese, 14.5 to 18.5%; Silicon, 0.3 to 1.3%; Copper, 1.8 to 2.2%; and Nitrogen, .08 to 0.15%, balance iron.

Vacuum Ultraviolet To Aid Research

A new vacuum ultraviolet spectrometer is expected to broaden basic research in the field of actinology and lead to improvements in materials used in electronics and fluorescent light sources such as those used in lamps and television tubes.

General Electric engineers who developed the new spectrometer revealed that it represents a great improvement over existing bulky and complex apparatus. The new device, designed for maximum flexibility of use, is moveable and weighs only 600 lb. Possible applications of the spectronmeter include making optical measurements of crystals, liquids, and gasses, photoconductivity measurements and determination of the exitation spectra of phosphors.

The source used for the vacuum ultraviolet radiation is a low voltage, high current, hydrogen discharge lamp which is powered by standard 110v A.C.

Vacuum ultraviolet rays are similar to solar rays found at altitudes in excess of 150 miles. A characteristic of rays of this wavelength is their

News Digest

inability to penetrate the earth's layer of atmosphere. G.E. scientists said the new ultraviolet source is not intended to be used as a means of studying the problems of space travel, but that it might be useful in assessing the effects of damaging radiation from atomic bomb blasts. High intensity ultraviolet rays generated by nuclear fission are presumed to be largely responsible for the serious flash burns experienced in the Hiroshima and Nagasaki explosions.

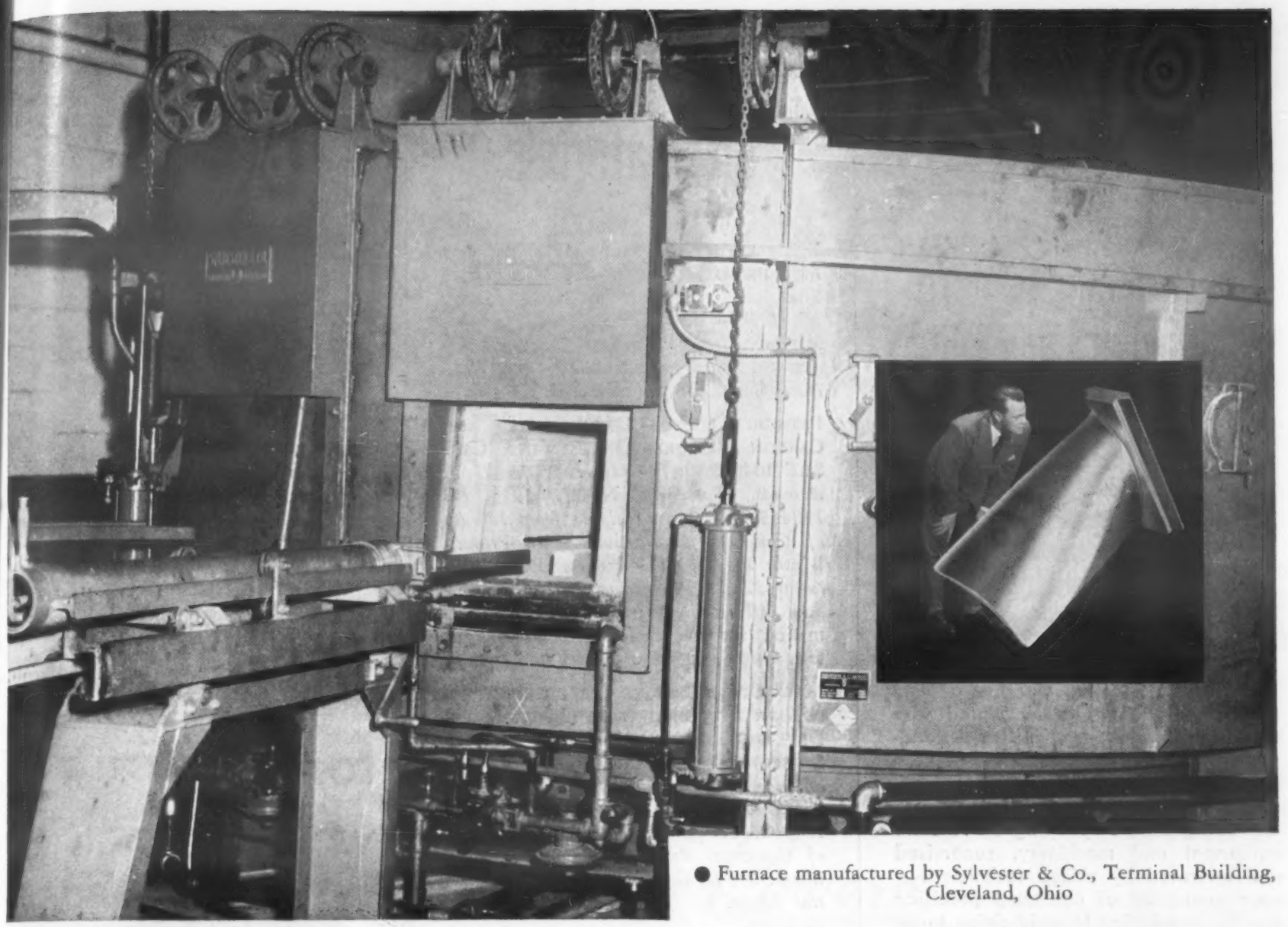
While the new spectrometer is not yet generally available to industry at this time, it is being used on projects which are devoted to producing a better phosphor for television tubes and fluorescent lamps, and for developing new materials for electronic devices.

Watch For 1954 Materials Show

The second Basic Materials Show, the product development show which had its premiere in New York last June, will be held in the International Amphitheatre, Chicago, May 17-20.

Attendance at the first show exceeded advance estimates by a large number and as a result the exhibition space at the second exposition will be more than doubled and the number of exhibitors will be increased by about 50%.

Exhibits are limited to companies producing basic materials which go into the manufacture of other products.



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Technical Reports on Materials

EVALUATION OF THE METHODS FOR MEASURING RESIDUAL STRESS AT THE SURFACE OF QUENCHED STEELS. *James W. O'Brien, 1949. PB 110481, 43 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.50, photostat $6.25*

FATIGUE LIFE OF DECARBURIZED AND CARBON RESTORED INVESTMENT CAST SAE 1040 STEEL. *Wade H. Shafer, U. S. Arsenal, Watervliet, N. Y., 1953. PB 110463, 161 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $6.25, photostat $21.25* Microstructure studies, carbon diffusion curves and related information for five different conditions of test.

MACROSCOPICHESCOYE OPREDELENIYE VODORODA B TVERDOI STALI (MACROSCOPIC DETERMINATION OF HYDROGEN IN SOLID STEELS). *E. V. Podoliskaya and E. G. Shumovskii. Translated by I. C. Lecompte, edited by F. A. Raven, 1953. PB 109902, 11 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $1.75, photostat $2.50.*

METALLOGRAPHY OF AN IRON ALUMINUM ALLOY PREPARED BY ELECTRICAL RESISTANCE SINTERING. *David Street, 1949. PB 110483, 32 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.25, photostat $5.00.* Investigation of changes in microstructure and other properties of an iron-aluminum alloy produced by electrical resistance sintering of a mixture of pure powders.

USE OF 8-HYDROXQUINOLINE FOR THE FLUORIMETRIC DETERMINATION OF ALUMINUM IN STEEL. *Warren H. McMullen, 1950. PB 110501, 33 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.25, photostat $5.00.* Fluorimetric quantitative determination of aluminum of low concentration is accomplished by use of a fluorimeter employing two photocells to measure fluorescence.

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PREPARATION OF REPRODUCIBLE BARIUM TITANITE CERAMICS. *R. M. Callahan and J. F. Murray, U. S. Naval Research Laboratory, 1953. PB 111188. Available from Office of Technical Services, U. S. Department of Commerce, Wash. 25, D. C. $.25* Conditions required for mixing binder, lubricant and wetting agent.

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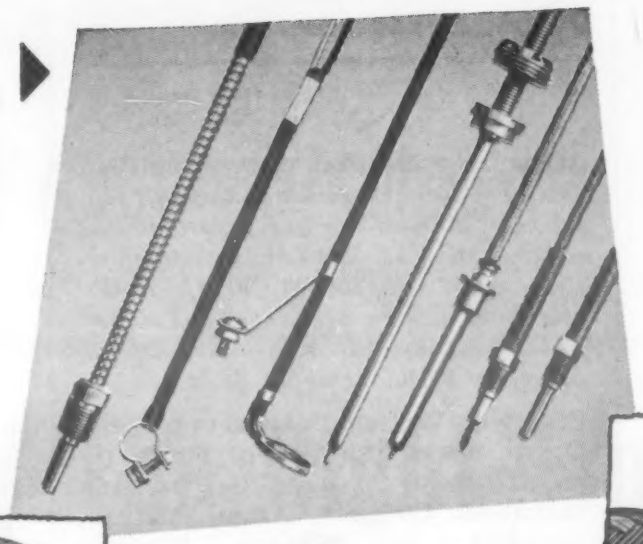

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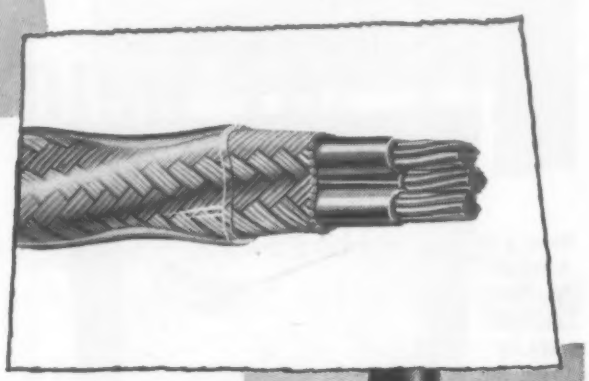

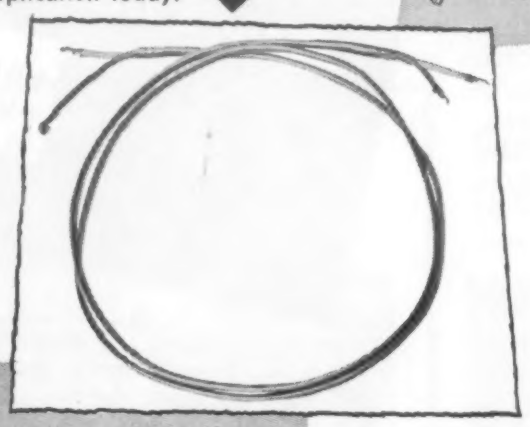

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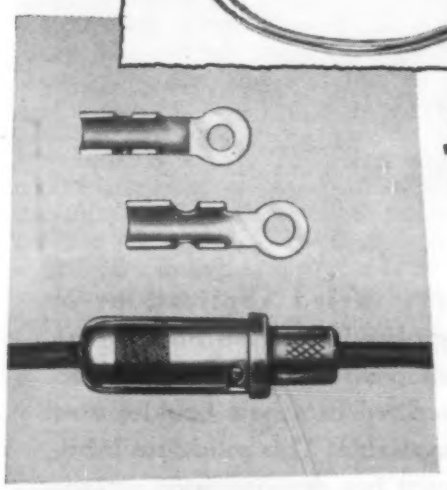

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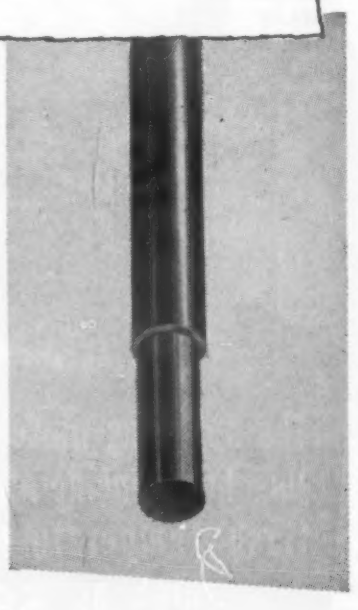

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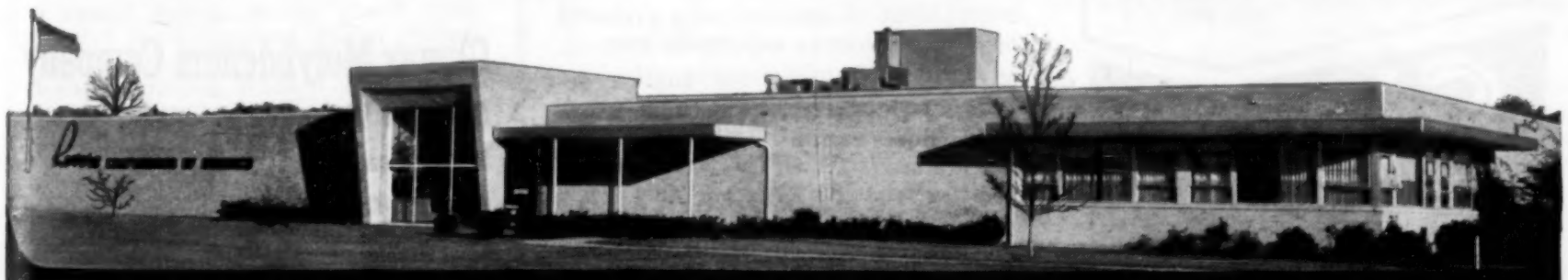

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continued from page 246

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EFFECT OF WELDING VARIABLES ON THE DEPTH, WIDTH AND AREA OF FUSION IN AN ALUMINUM ALLOY, USING THE ALTERNATING CURRENT, ARGON-SHIELDED TUNGSTEN ARC WELDING PROCESS. *Jack W. Cuthbert, 1949. PB 110482, 73 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D.C. Microfilm $3.50, photostat $10.00.* Tests conducted on 52S-O aluminum to establish current and speed of travel conditions for welding.

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PRESSURE DEPENDENCE OF RESISTANCE OF GERMANIUM. *Julius H. Taylor, University of Pennsylvania, 1950. PB 109761, 29 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.00, photostat $3.75.* General theory and methods for measurement of changes in conductivity due to changes in pressure in the range 1000-5000 psi.

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ULTRASONICS APPLIED TO SOLIDIFICATION AND SOLID-STATE TRANSFORMATION. *Byron Jones, Aeroprojects, Inc., West Chester, Pa., 1951. PB 110465, 80 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $3.50, photostat $10.00.* Ultrasonic energy applied to 24S and 75S aluminum alloys after solution heat treatment. Effect of age hardening evaluated by Brinell hardness and tensile tests.

X-RAY INVESTIGATION OF THE STRUCTURE AND LATTICE PARAMETERS OF MAGNESIUM-LITHIUM-ALUMINUM TERNARY ALLOYS AT ROOM TEMPERATURE AND AT 600 F. *Raymond J. Towner, 1950. PB 110478, 39 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.25, photostat $5.00.*

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How to Find The Right Finish for Zinc

Plastisol coating outlasts metal 4 to 1 in corrosive application

Here's a case showing the extraordinary protection that can be given to metals.

Bleach reduction chambers of a noted chemical producer were coated with a Unichrome Plastisol Compound. This user reported that the coating gave 4 times longer service than even special alloy metals before requiring maintenance! The exceptional chemical resistance displayed by these vinyl coatings is fortified by the thickness they develop—up to 3/16". Tough and elastic, they bake to stable form at 350° F. The Technical Service Department of United Chromium can be consulted on the suitability of these compounds for any specific application.

Formula for a chromium-bright lasting zinc finish

Here's the "substitute" finish that became standard for so many products because of its quality. First, a plate of .0002" to .0005" of zinc on the product. Then a quick dipping in Unichrome *Clear Dip* Solution for brilliance and corrosion resistance. Lastly, a Unichrome Clear Enamel which seals in the brilliance despite handling and exposure.

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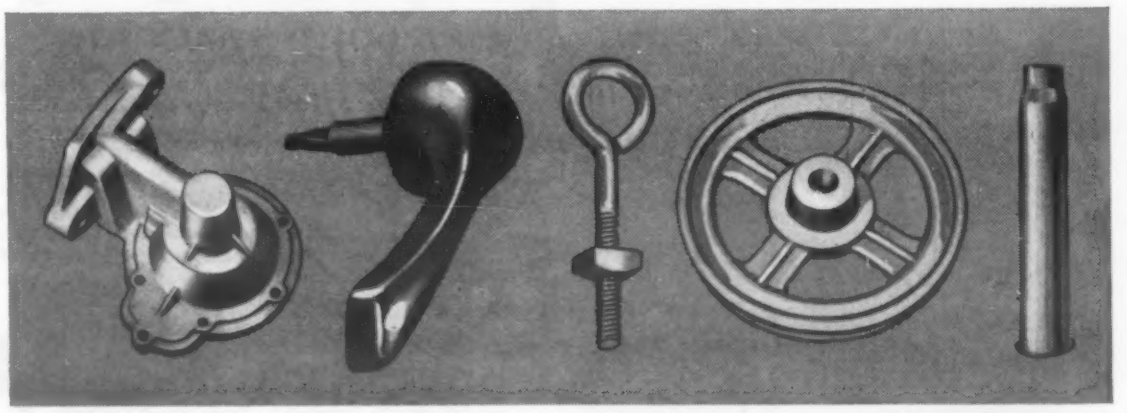

Improved chromate-treating methods have been largely responsible for the increased use of zinc as a finish in the past several years. For several reasons. They give zinc the extra protection against corrosion required by Government specifications. They can produce attractive decorative finishes. They provide a base for better adhesion of paint and lacquer.

Today, United Chromium offers metal finishers and designers the most complete line of chromate treatments available. This wide choice results in substantial benefits because it means a finish not "almost as good as" but rather the one that best meets the user's needs.

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A chart to save time and help locate the best-suited chromate-treating material is available. Also Bullein CC-1 describing Unichrome Dips and Anozinc. Write for your copies. **Trade Mark*

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continued from page 248

PB 110497, 129 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $5.00, photostat $16.25.

EFFECT OF THE CATALYTIC ION ON OBTAINING CRACK FREE STRUCTURES IN CHROMIUM PLATING. *Herbert L. Kee, 1950. PB 110499, 37 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.25, photostat $5.00.*

RAPID METHOD FOR THE SEMI-QUANTITATIVE SPECTROGRAPHIC ANALYSIS OF A WIDE RANGE OF MATERIALS, *An A. E. R. E. Report. F. T. Birks. Great Britain Ministry of Supply. Atomic Energy Research Establishment, 1953. Available from British Information Services, 30 Rockefeller Plaza, New York, N. Y. $.35.*

DEVELOPMENT OF TEST METHODS FOR EVALUATION OF MATERIALS USED AS THREAD AND ANTI-SEIZE COMPOUNDS, QUARTERLY REPORT, OCT.-DEC. 1951. *John W. Cunningham and William A. Moore. Southwest Research Institute, San Antonio, Texas, 1952. PB 110476, 33 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.25, photostat $5.00.*

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ANALYSIS OF THE THEORY, HISTORY, AND DEVELOPMENT OF METHODS OF CONTINUOUS CASTING OF METALS. *Robert L. Seaman, 1950. PB 110470, 93 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $4.25, photostat $12.50.*

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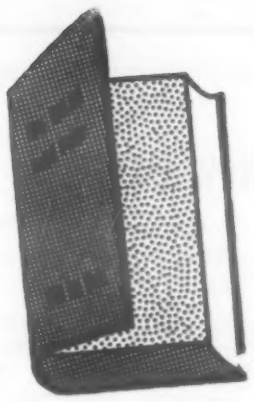
APPRAISAL OF RESEARCH AND DEVELOPMENT OF PERMANENT MAGNET MATERIALS. *National Research Council. Division of Engineering and Industrial Research. Minerals and Metals Advisory Board, 1953. PB 109913, 211 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $7.75, photostat $27.50.*

COMPARISON OF FRAMING IN WELDED STEEL AND ALUMINUM, INCLUDING THE DESIGN OF WELDED STEEL AND ALUMINUM PLATE GIRDERS AND TRUSSES. *Gordon Dickson Orr, 1950. PB 110502, 87 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $3.75, photostat $11.25.*



BOOK REVIEWS

Fatigue of Metals

FATIGUE OF METALS. By R. Cazaud. *Translated from the French by A. J. Fenner. Published by the Philosophical Library, New York 16, N. Y., 1953. Cloth, 6 by 9 in. 334 pp. Price $12.50.*

This book is a comprehensive survey of the behavior of metals under cyclic stresses by an authority who has spent many years in investigation of the subject. Although the original French edition was published in 1948, the translator has included some research work completed since that time and the book is an up-to-date presentation.

The work contains a comprehensive discussion of the separate or combined influences of stress fatigue properties of a wide range of metals and alloys. The remainder of the book deals with the effects of sharp changes in section, discontinuities and other factors which are not constant on the fatigue life. This review of practice and experience should be helpful in the selection of materials and improvements in design to minimize fatigue failures.

The book is well illustrated and contains many tables of data on fatigue properties. It contains a comprehensive bibliography which is particularly rich in references to European sources. It should be on the reference shelf of every engineer engaged in a study of the fatigue of metals.

Correction

The correct subscription rate of *Metal Industry Handbook* (reviewed in the September, 1953 issue) is $10.00.

(More Reviews on page 252)

Book Reviews

(continued)

Other New Books

HANDBOOK OF MATERIAL TRADE NAMES. *By O. T. Zimmerman and Irvin Lavine. Published by Industrial Research Service, Dover, N. H., 1953. 7½ by 10¼ in. 794 pp. Price $20.00.* The new and enlarged edition of this comprehensive volume contains listings of over 15,000 trade name materials. Each name which is a registered trade mark is clearly identified as such and non-registered, generic and common names are appropriately designated. The use of a classification system has been added to this edition. Finally, the book contains an expanded company directory section which includes not only the name and mailing address of each company, but also lists the company's products that are described in the book.

SYMPOSIUM ON PLASTICS TESTING—PRESENT AND FUTURE. *Published by The American Society for Testing Materials, Philadelphia 3, Penna., 1953. Paper, 6 by 9 in. 76 pp. Price $2.00.* The papers included here were presented at the Symposium on Plastics Testing—Present and Future, which was organized by the ASTM Committee D-20 on Plastics and held at the Fifty-fifth Annual Meeting of the Society in New York in June of 1952. The following titles show the wide range of topics covered: "The Measurement and Significance of the Mechanical Strength Properties of Plastics", C. H. Adams; "Measurement of the Effect of Temperature on Some Physical Properties of Plastics", J. P. Tordella, A. C. Webber, and E. B. Cooper; "Measurement of Color, Gloss and Haze", Harry K. Hammond and George W. Ingle; "The Effects of Molding Conditions Upon the Permanence of Plastics", J. L. Williams and J. W. Mighton; "Residual Stresses in Phenolic Plastics", L. E. Welch and H. M. Quackenbos, Jr.

CORROSION (A SERIES OF PAPERS REPRINTED FROM "RESEARCH" VOLUME 5, 1952). *Published by Interscience Publishers, Inc., New York 1, N. Y., 1953. Paper, 7 by 9 in. 63 pp. Price $1.75.* The titles of these papers reprinted from an English publication are as follows: "Metallic Corrosion"; "Prevention of Corrosion of Ships in Sea Water by Means of Cathodic Protection"; "Prevention of Corrosion of Ships in Sea Water II. Cathodic protection by impressed currents"; "Prevention of Corrosion by Metallic Coatings"; "The Protective Action of Paints"; "Prevention of Corrosion by Means of Inhibitors"; "Corrosion Testing"; "Vapour Phase Inhibitors".

SYMPOSIUM ON STRENGTH AND DUCTILITY OF METALS AT ELEVATED TEMPERATURES. *The American Society for Testing Materials, Philadelphia 3, Penna., 1953. Paper, 6 by 9 in. 249 pp. Price $3.25.* The papers and discussions contained here were presented at the first, third and sixth sessions of the Fifty-fifth Annual Meeting of the American Society for Testing Materials held in New York, June 23, 1952. This symposium was sponsored by the Joint ASTM-ASME Committee on Effect of Temperature on the Properties of Metals.

LINEAR SCALE NON-LOGARITHMIC SLIDE RULES. *By Morris L. Groder. Published by G & G Corp., Brooklyn 29, N. Y., 1953. Paper, 5 by 8 in. 64 pp. Price $2.98.* The principles described in this volume are presented as tools for constructing general, special, and emergency slide rules. The illustrations reveal that the shape and size of these computers do not conform with the commonly accepted versions of the slide rule. However, the author has constructed linear scale slide rules on logarithmic slide rule bodies. The computers described here were expressly designed from the viewpoint of convenience in construction and application.

line of steel weldments engineered and fabricated by this company. (40)

Steel Tubing. Summerill Tubing Co., Div. Columbia Steel and Shafting Co., 8 pp, ill. Cold drawn steel tubing for hydraulic applications. (41)

Alloyed Gray Iron Castings. Superior Foundry Inc., 8 pp, ill. Gives advantages, specifications, and illustrates production methods of Superior's electric furnace process for producing alloyed gray iron castings. (42)

Strip Steels, Etc. Superior Steel Corp., 12 pp, ill. Detailed data on the proper selection of Superior strip steels, stainless steels, SuVeneer Clad Metals, alloy and spring steels, etc. (43)

Precision Casting. Thompson Products, Inc., Metallurgical Products Div., 8 pp, ill, No. MP-53-1. Discusses the Intricast process of precision casting any castable metal or alloy. (44)

Steels. Timken Roller Bearing Co., Steel & Tube Div., Canton, Ohio. Complete catalog of steels produced by this company. Request on company letterhead direct from Timken.

Steel Forgings. Titusville Forge Div., Struther Wells Corp., 8 pp, ill. Describes facilities for precision forging of parts regardless of size, metal or alloy. Shows numerous parts produced. (45)

Cylinder-Finish Tubing. Tube Reducing Corp., 4 pp, ill, No. R-7. Illustrates close tolerances and good surface finish obtained in compression formed tubing. (46)

Ferro-Alloys and Metals. Vanadium Corp. of America, 24 pp, ill. "The Vancoram Review" presents technical articles on applications and developments in ferro metallurgy especially concerned with vanadium alloys. (47)

Prealloyed Steel Powders. Vanadium-Alloys Steel Co., 4 pp, ill. Discusses advantages and manufacture of prealloyed steel powders claimed to give qualities available in wrought steels. (48)

Metal Shapes Tubing. Van Huffel Tube Corp., 24 pp, ill. Tables for metal shapes, lockstream tubing, butted tubing, welded tubing, angles and channels. (49)

Screw Machine Parts and Other Metal Forms. Worthington Corp., 7 pp, No. W-350-B5C. Describes valves, flanges, hose nipples, bars, welding electrodes and screw machine products available. (50)

Mechanical Tubing. Youngstown Sheet & Tube Co., 4 pp, ill. Features size and wall thickness of a complete line of Yoloy electric weld mechanical tubing. (51)

Castings. Meehanite Metal Corp. A handy slide-rule type chart giving complete physical specifications for four basic types of Meehanite castings. (87)

Nonferrous Metals • Parts • Forms

Aluminum Castings Alloy. Acme Aluminum Alloys Inc., 8 pp, ill. Technical data on Acme Almag 35, a light weight aluminum casting alloy combining high strength, ductility and impact resistance. (52)

Bronze Alloys. American Manganese Bronze Co., Rhawn & Torresdale Ave., Philadelphia, 46 pp. Data on properties and specifications of bronze alloys for casting. Request direct from company on business letterhead.

Magnesium Castings. American Radiator and Standard Sanitary Corp., 8 pp, ill, No. 377. Illustrates the facilities of this company for producing magnesium sand molded castings. (53)

Aluminum Alloys. Apex Smelting Co., 24 pp, ill. Discusses composition, typical mechanical properties, heat treatments and basic foundry applications of the standard aluminum alloys produced by Apex. (54)

Precision Investment Castings. Arwood Precision Casting Corp., 16 pp, ill. Informative article on precision investment castings. Includes table of ferrous and nonferrous alloys recommended as most adaptable for this process. (55)

Magnesium. Brooks & Perkins, Inc., 8 pp, ill. Describes the facilities and services of this company for fabricating magnesium. (56)

Pre-Coated Metal Strip. Coated Coils Corp., 3 pp, ill. Versatile color finishes produced by an exclusive process is illustrated by actual sample of Enamelstrip, the metal coil pre-coated in color. Address inquiries to Mr. Marvin Richfield, Adv. Mgr., 513 W. 30th St., New York, N.Y.

Custom Extrusions. Conneaut Rubber & Plastics Co., 4 pp, ill, No. CR-53. Facilities of this company for producing a variety of precision made extrusions. (57)

Die Cast Parts. Dollin Corp. Bulletin describes advantages of using this company's facilities for production of small zinc or aluminum precision cast parts. (58)

Nickel Alloy Products. Driver-Harris Co., 4 pp, ill. *D-H Alloy Craftsman* describes various applications of Nichrome and monel wires and forms. (59)

Magnesium and Aluminum Castings. Eclipse-Pioneer Div. Foundries. "Book of Facts" shows company's facilities for custom-making aluminum and magnesium castings. (60)

Die Cast Parts. The Electric Auto-Lite Co., Die Casting Div., 16 pp, ill, No. G137. Describes facilities for economical manufacture of quality die castings. (61)

Chromium Carbides. Firth Sterling Inc., 4 pp, ill. Properties and uses of chromium carbide-nickel and chromium carbide-titanium carbide-nickel compounds. (62)

Aluminum Alloy. Frontier Bronze Corp. Data on Frontier 40-E aluminum alloy, combining high strength, good shock and corrosion resistance, machinability. (63)

Copper-Clad Aluminum. General Plate Div., Metals & Controls Corp., 6 pp, No. 702C. Technical data on Alcuplate, a composite metal consisting of a layer of aluminum on which a thin layer of copper is clad on either or both sides. (64)

Copper and Brass Tubing. H & H Tube & Mfg. Co. Describes a complete line of seamless braze and lock seam copper and brass tubing. (65)

Short Run Stampings. HPL Mfg. Co., 4 pp, ill, No. 718. How this company's facilities permit the rapid, inexpensive production of small lots (25 to 25,000 pieces) of stamped parts for experimental or development work. (66)

Die Castings. The Hoover Co., 12 pp, ill, No. 853. Shows this company's facilities for producing zinc and aluminum die castings. Includes design helps, describes applications. (67)

Nickel Alloys. International Nickel Co., Inc., 32 pp, ill. Revised edition gives complete data on nickel alloys in railroad equipment. (68)

Precision Cast Parts. The Jelrus Co., Inc. Advantages of centrifugal precision casting for custom manufacture of complex parts accurately and quickly. (69)

Sleeve Bearings. Johnson Bronze Co., 3 pp, ill. Technical data show how to select the correct bearing material. (70)

Warehouse Service. Korhumel Steel & Aluminum Co., 6 pp, ill. Description of personalized warehouse service for steel, aluminum, phosphor bronze materials and other services. (72)

Magnesium. Magline Inc., 8 pp, ill. Facilities for fabricating magnesium and producing sand castings. (73)

Titanium and Its Alloys. Mallory-Sharon Titanium Corp., 16 pp, ill. Current data on the properties of various grades of titanium and titanium alloys. (74)

Die Castings. Paramount Die Casting Co., 4 pp, ill. Facilities of this company for producing aluminum, magnesium and zinc die castings. (75)

Die Castings. Racine Die Casting Co., 8 pp, ill. Zinc or aluminum castings of various sizes illustrated, with facilities for their manufacture. (76)

Bushings. Randall Graphite Bearings, Inc., 12 pp, ill, No. 100. Complete price list of bronze bushings and specially grooved bushings; specifications of bored and solid bronze bars. (77)

Titanium and Its Alloys. Republic Steel Corp., 32 pp, ill, No. 588. A practical working manual presenting some basic and fairly well substantiated data on commercial quality titanium and its alloys. (78)

Lockseam Tubes. Revere Copper and Brass, Inc., 46 pp, ill. Contains comprehensive listing of more than 100 shapes of lockseam tube and rolled moldings of interest to manufacturers in the automotive, house furnishings, hardware and farm implement fields. (79)

Roll Formed Aluminum. Reynolds Metals Co., 8 pp, ill. Description of production of aluminum continuous roll-formed shapes. (80)

Aluminum Strip. Scovill Mfg. Co., 20 pp, ill. Booklet covers 64 years of work on aluminum by Scovill, and includes specifications of alloys supplied to industry. (81)

Tungsten Carbide Parts. Sintercast Corp., 9 pp, ill. Complete information on a variety of custom-made tungsten carbide components. (82)

Tungsten and Molybdenum. C. Tennent & Sons Co., 20 pp, ill. Tungsten and molybdenum products, in both sheet and wire form. Includes sizes and physical properties. (83)

Light Metal Castings. Thompson Products Inc., 8 pp, ill. Describes a complete line of precision die castings for various industrial uses. (84)

MANUFACTURERS' LITERATURE

Aluminum Wire. U. S. Rubber Co., 30 pp, tables. A handbook describing the uses and properties of aluminum for power and lighting wire. (85)

Bearings, Bushings. Wakefield Bearings Corp., 8 pp. Booklet illustrates Graves, Coprex and Woodex oilless and self lubricating bearings, bushings and machine parts. Also, 12-page booklet listing standard sizes of bearings. (86)

Nonmetallic Materials • Parts • Forms

Plastic Moldings. Accurate Molding Co. Describes facilities for producing precision plastic moldings. Case histories given. (90)

Polyethylene Resins. American Agile Corp., 8 pp. Comprehensive summary of physical and chemical properties of Agilene polyethylene resins fabricated by this company. (91)

Molded Plastics, Hard Rubber. American Hard Rubber Co., 80 pp, ill. Handbook of properties, tolerances and weights; design techniques, machining and finishing methods for this firm's hard rubbers and plastics. (92)

Hermetic Terminals. American Lava Corp., 4 pp, ill, No. 524. Metallized ceramic materials with hermetically sealed electrical components. (93)

Emulsion Adhesive. American Resinous Chemical Corp., 1 p, No. A44. Technical data sheet announcing the qualities of a new emulsion adhesive for heat resistant bonds to paper, fabric, leather and other surfaces. (94)

Extruded Plastics. Anchor Plastics Co., 12 pp, ill. Applications of thermoplastic rods, tubes and shapes. Summary of properties of plastics materials with usage table. (95)

Plastic Pipe. Anesite Co., 2 pp, ill. Specifications and applications of Black-Buty plastic pipe, designed to combat corrosion and avoid paraffin build-up in gathering lines and salt water disposal systems. (96)

Aluminum Adhesive. Armstrong Products Co., 6 pp, ill. Features the properties of adhesive for bonding aluminum at contact pressure. (97)

Plastics Packaging Materials. Bakelite Div., 8 pp, ill, No. G-12. Properties, description and applications of Bakelite and Vinylite coatings, molded and blown products, sheeting and adhesives for packaging. (98)

Plastic Sheet. Campco Div., Chicago Molded Products Corp., 4 pp, ill. Applications, information and engineering data on Campco S-300, polystyrene rubber in rigid sheet form. (99)

Wear Resistant Carbides. Carboloy Dept., General Electric Co., 12 pp, ill, No. WR-107. Latest information on the use of cementing carbides in wear-proofing pulverizing equipment used in applications ranging from processing alfalfa to pulverizing powdered metal. (101)

Plastic Pipe. Carlon Products Corp., 4 pp, ill. Contains factual informative answers to most frequently asked questions about carbon flexible plastic pipe and carbon rigid pipe. (102)

Optically Clear Plastic Sheets. Cast Optics Corp., 8 pp, ill. Presents uses, features and fabrication of various optically clear rigid plastic sheets. (103)

Plastics. Ciba Co., Inc., Plastics Div., 625 Greenwich St., New York 14, N. Y. Complete technical data on the physical properties and recommended procedures for the successful use of Araldite Resins for individual fabricating needs. Write direct to Ciba on company letterhead

High Temperature Insulation. Continental Coatings Corp., 8 pp, ill. Properties, typical applications and methods of applying Hylag insulation for high temperature equipment. (104)

Sheet and Fiber Specialties. Continental-Diamond Fiber Co., 12 pp, ill, No. GF-54. Tensile, flexural, shearing and compressive strengths and other material qualities of laminated plastics sheets, tubes, rods, teflon sheets and tapes and other plastic products. (105)

Molded Plastics. Dayton Rogers Mfg. Co., 4 pp, ill, No. 242. Describes this company's facilities for low cost production of molded plastics in small lots. Gives costs of sample products. (106)

Plastic Bearing Material. Dixon Saddle Co., 2 pp. Typical properties of Rulon, a plastic bearing material that requires no lubrication. (107)

Plastic Lined Fittings. The Dow Chemical Co., 32 pp, ill, No. SL6-N-250. Properties, design data and applications of Saran-lined steel and iron pipe fittings and valves. (108)

Silicone Rubber. Dow Corning Corp. Technical data sheets on properties, applications and plating and coloring two new silicone rubber stocks of high tensile and elongation set characteristics. (109)

Glass Products. Dunbar Glass Corp., 4 pp, ill. Descriptions of this firm's various industrial glasses. Explains advantages of glass to the designer and gives physical properties. (110)

Phenolic Molding Compounds and Resins. Durez Plastics & Chemicals, Inc., 4 pp, ill. Includes types, properties and uses of a variety of Durez phenolic molding compounds, industrial resins and coating resins. (111)

Glass-Reinforced Plastics. The Dynakon Corp., 7 pp. Gives mechanical, electrical, chemical and fabricating properties of Dynakon's glass-reinforced plastics materials. (112)

Laminated Plastics. Formica Co., 16 pp, ill. Describes 50 standard grades of Formica laminated plastics for industrial usage. Includes a new edition of the Formica comparator chart. (113)

Plastic Parts. Franklin Plastics, Div. of Robinson Industries, Inc., 6 pp, ill. Illustrates variety of plastics products and discusses this company's injection molding facilities. (114)

Rubber-to-Metal Adhesive. General Tire & Rubber Co., Chemical Div., 8 pp, ill, No. 4016. Complete data on Kalabond rubber-to-metal adhesive for non-corrosive solvent-resistant bonding. (115)

Silicone Rubber. General Electric Co., Chemical Div., 24 pp, ill, No. CDS-3. Includes comprehensive information on properties, applications, classes and design applications of G-E silicone rubber. (116)

Fiber Glass Laminate. The Glastic Corp., 7 pp, ill. Describes Glastic grade MM fiber glass-reinforced polyester laminates and gives mechanical, electrical and chemical properties. (117)

Plastic Adhesive. Goodyear Tire & Rubber Co., Inc., 24 pp, ill, No. S-9416. Properties, applications, specifications and data sheets of Pliobond, a quick-setting plastic adhesive that bonds anything to anything. (118)

Packing. Greene, Tweed & Co., 16 pp, ill, No. PC-101. Specifications, descriptions and applications of Palmetto packing, gaskets, asbestos rope and wick. (119)

Rubber Sheet Packing. Hamilton Rubber Mfg. Co., 4 pp, ill, No. 853. Data on weight, tensile and hardness of rubber sheet stocks for use in packing. (120)

Polyvinyl Chloride. H. N. Hartwell & Son Inc., 6 pp, ill, Nos. 2B and PF. Data sheet and basic information on Boltaron 6200, a nonplasticized polyvinyl chloride. (121)

Plastics. Heil Process Equipment Corp., 3 pp, ill, Nos. 752, 753 & 754. Discusses the use of Rigidon plastics exhaust hoods, duct fittings and ventilating ducts. Specifications included. (122)

Plastics. Heresite & Chemical Co., 24 pp, ill. Oil-free thermosetting phenolic coatings, thermosettings and thermoplastic resins, moldings, compounds, synthetic rubber coating sheets and molded forms. (123)

Plastisols. Houghton Laboratories Inc., 4 pp, ill. Includes typical applications and specifications of the Hysol 3000 series of plastisols—dispersions of high molecular weight polyvinyl chloride resins in selected liquids called plasticizers. (124)

Balsa Wood. International Balsa Corp., 4 pp, ill. Explanatory bulletin describing why balsa wood must be kiln-dried. (125)

Plastics for Process Equipment. Johns-Manville Corp., 8 pp, ill. Technical data for insulations, refractories, transite pipe, packings and gaskets, metal raschig rings and transite sheets. (126)

Rigid Polyvinyl Chlorides. Kaykor Industries Inc., Div. of Kaye-Tex Mfg. Corp., 6 pp. Chemical and physical properties of Vyflex rigid polyvinyl chloride plates and sheets. (127)

Molding Powders, Etc. M. W. Kellogg Co., 20 pp. Buyer's Guide gives complete addresses of firms producing molded and fabricated materials and products made of Kel-F, a trifluorochloroethylene polymer offered by Kellogg. (128)

Polystyrenes. Koppers Co., Inc., No. C-2-169. Features a table giving all the properties of a complete line of straight and modified Koppers polystyrenes. (129)

Glass. Lancaster Lens Co., 8 pp, ill. Twenty-one case histories of a wide variety of glass part applications. (130)

Fiber Glass Reinforcements. Libbey-Owens Ford Glass Co., 12 pp, ill, No. F-1. Describes company facilities and their applica-

MANUFACTURERS' LITERATURE

tions, gives specifications and descriptions of fiber glass yarns and insulation. (131)

Electrical Insulation. Louthan Mfg. Co., 13 pp, ill, No. 49-E. Uses and specifications of Louthan insulations in mechanical, electrical, thermal and electronic fields. (132)

Industrial Porcelains. McDaniel Refractory Porcelain Co., 24 pp, ill. Descriptions, outstanding features and specifications of various types of industrial porcelain parts. (133)

Glass Products. McKee Glass Co., 16 pp, ill, No. 12-68. Describes types of glasses manufactured, their applications and facilities for large-scale production. Illustrates numerous products for home and industry, including electrical, laboratory, television and marine equipment. (134)

Electrical Insulating Material. Mica Insulator Co., 4 pp, ill. Complete data on Isomica, a new and improved electrical insulation with higher dielectric strength, greater uniformity and better physical characteristics. (135)

Rubber Products. Midwest Rubber Co., 4 pp, ill. Features, characteristics, uses and requirements of this company's rubber products. (136)

Potting Compound. Minnesota Mining & Mfg. Co., 12 pp. Industrial data necessary for successful use of dielectric sealer originally formulated for the aircraft industry. (137)

Polyurethanes. Monsanto Chemical Co., 15 pp, No. 151. Description of a new type of product incorporating diisocyantes prepared from a polyfunctional hydroxyl compound for use as adhesive for bonding rigid materials. (138)

Carbon Products. Morganite, Inc., 8 pp, ill, No. 1f. Specifications of various carbon bearings and bushings. Also properties of six series of Morganite carbon products. (154)

Glass Bonded Mica. Mycalex Corp. of America, 24 pp, ill. Design information for parts to be machined from glass bonded mica. (139)

Laminated Plastics. National Vulcanized Fibre Co., 16 pp, ill, No. 1b/12. Physical electrical, mechanical and chemical properties of Phenolite laminated plastic sheet, rods, tubing and special shapes. Properties of National Vulcanized Fibre also listed. (140)

Foam Plastic. Nopco Chemical Co., 28 pp, ill. Illustrates foam plastic in construction, electronic, packaging, reinforcement and vibration damping. (141)

Molded Nylon. Nylon Molded Products Corp., 4 pp, ill. Presents easy method of calculating the material cost for a nylon part. (142)

Rubber. Ohio Rubber Co., 4 pp, ill, No. F-426. Detailed tabulation of the properties of natural rubber and rubberlike materials. (143)

Fiber Glass. Pittsburgh Plate Glass Co., 4 pp, ill. Lists advantages of using fine glass fiber mat for sound heat insulation application. (144)

Plastic Glass Laminate. Plastilight Inc., 1 p, ill. Technical data on Epoglass (epoxy resin laminate) for use in electrical and electronic systems, such as printed circuits. (146)

Styrene Resins. Reichhold Chemicals Inc., Technical Bulletins Nos. 1, 2, 3, 4 and 5. Applications, characteristics, catalysis and mixing recommendations of Polylite polyester resins. (147)

Synthetic Flexible Tube Assemblies. Resistoflex Corp., 4 pp, ill. Briefly gives chemical and physical properties obtained with synthetic tubes. Describes types of construction, where to use, and how they solve design problems. (148)

Acrylic Plastic Molding Powder. Rohm & Haas Co., 12 pp, ill, No. PL86A. Designs, properties and applications of a variety of Plexiglas acrylic plastic molding powders. (149)

Closed Cellular Rubber. Rubatex Div., Great American Industries Inc., 8 pp, ill. Nonporous foamed rubber products for sealing, gasketing, cushioning, packaging and other uses. (150)

Teflon. Sparta Heat-Treat Co., Plastics Div., 4 pp, ill. Illustrates various Teflon moldings produced by Sparta, and includes a detailed table of typical properties of molded Teflon TF-1. (151)

Rubber Parts. Stalwart Rubber Co., 16 pp, ill, No. 51SR-1. Describes applications and fabrication of rubber compounds designed to resist temperature, abrasion, chemicals and weathering. (152)

Ceramic Products. Stupakoff Ceramic and Mfg. Co., 52 pp, ill, No. 951. Drawings and dimensions of more than 500 steatite products, chart of technical characteristics of Stupakoff ceramics, and standards for steatites. (153)

Synthetic Rubber Products. Western Felt Works, Acadia Synthetic Products Div., 6 pp, ill. Describes various types of molded, extruded, roll die cut and lathe cut synthetic rubber parts and sheets. (155)

Finishes • Cleaning and Finishing

Aluminum Coating. Anodic Inc., 4 pp, with samples. Hard coating for aluminum, its properties and uses. (159)

Resin Coatings. Bakelite Co., 8 pp, ill. Advantages and uses of synthetic resin base coatings of the chemical industry. Presents 16 case histories of actual industrial coating applications of Bakelite and Vinylite. (160)

Metallurgical Polishing Materials. Buehler Ltd., 20 pp, ill. Samples and descriptions of such polishing materials as emery, aluminum oxide and silicon carbide papers and polishing cloths. (161)

Hard Facing. Cleveland Hard Facing Inc., 4 pp, ill. Service for hard facing parts subject to intense wear conditions. (162)

Spray Painting. Conforming Matrix Corp., 5 pp, ill. Gives description, uses and advantages of this firm's spraying masks, mask washing machine, and spray painting equipment. (163)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 261 or 262

Wet Blasting. Cro-Plate Co., Inc., 8 pp, ill. Deburring, die and mold polishing, scale removal and honing with both regular velocity and high velocity pressure blast and wet blast equipment. (164)

Wear Resistant Coating. Electrolyzing Corp., 16 pp. Detailed data on the Electrolyzing Process for increasing the life and efficiency of metal parts subjected to wear, abrasion and corrosion. (165)

Protective Coating. Flexrock Co., Protective Coating Div., 4 pp, ill. Complete data on Flexcoat 311, a vinyl-acrylic base industrial coating that stops corrosion and contamination. (166)

Washing and Drying Machines. Industrial Machine Corp., 10 pp, ill. Profusely illustrates a complete line of industrial washing and drying machines for washing, rinsing, slushing and drying operations. (167)

High-Pressure Cleaners. J. P. Mfg. Co., 4 pp, ill. Typical applications of the new 2500 Series Whirlpool high pressure cleaners that degrease, wash, strip and clean in one operation. (169)

Barrel Finishing. Lord Chemical Corp., 32 pp, ill. Introductory bulletin describes various compounds for precision barrel finishing. (170)

Industrial Enamel. Maas & Waldstein Co., 2 pp, No. 520. Data sheet for industrial multicolored enamels. (171)

Mechanical Finishing. Mech-Finish Corp., 4 pp, ill. Low cost deburring and finishing abrasives chips. (172)

Silicone-Base Finish. Midland Industrial Finishes Co. Brochure describes silicone-base finish, said to resist heat of 500 F without discoloration. (173)

Solvent Cleaner. Mitchell-Bradford Chemical Co., 4 pp, ill. Description of a multipurpose solvent and wetting agent for many industrial uses. (174)

Zinc Dust Paints. New Jersey Zinc Co., 36 pp, ill. Characteristics and uses of zinc dust paints, most adherent paints for galvanized iron and steel zinc. (175)

Wrinkle Finishes. New Wrinkle Inc., ill. Folder shows typical products utilizing Wrinkle finishes. (176)

Electrocleaning Zinc-Base Die Castings. Oakite Products Inc., 6 pp, No. F-8654. Discusses Oakite composition No. 95, a new anodic conditioner for zinc-base die castings. (177)

Industrial Brushes. Pittsburgh Plate Glass Co., Brush Div., Dept. W-4, 3221 Frederick Ave., Baltimore, Md. Case histories indicate economies available to users of Pittsburgh brushes. Request on company letterhead direct from this company.

Mechanical Finishing. Roto-Finish Co. Folder describes uses and economies of Roto-Finish tumbling-type equipment for precision grinding, deburring and coloring metals. (178)

Metal Treatment. Specialty Coatings, Inc. Data sheet and sample of Vinsynite for metal treatment and maintenance. (179)

Zirconium Glazes for Ceramics. The Titanium Alloy Mfg. Div., 30 pp. Description, uses and properties of TAM zirconium glaze opacifiers. (180)

Liquid Honing. Vapor Blast Mfg. Co., 4 pp, ill. Equipment for surface finishing by liquid honing, specifications and dimensions of equipment. (181)

MANUFACTURERS' LITERATURE

Heat Treating • Heating

Case Hardening Process. American Gas Furnace Co. Principles of "Ni-Carb" case-hardening, its advantages, and descriptions of AGF furnaces for the process. (186)

Box Muffle Furnaces. Burrell Corp., 4 pp, ill, No. 315. Includes specifications and prices of five "Unit Package" box muffle furnaces for low and high temperature testing operations. (187)

Furnace Heating Elements. Carborundum Co., Globar Div. Complete data on Globar silicon carbide heating elements, said to be efficient, safe and easy to repair. (188)

Hardening Equipment Control. Cincinnati Milling Machine Co., 4 pp, ill. Control unit for fuel, gas, water and electric power for a wide range of selected hardening operations. (189)

Radiant Glass Panels. Corning Glass Works, 8 pp, ill, No. B-86. Uses and features of Pyrex glass panels coated with electrically conducting coating for radiant heating and drying. (190)

Porcelain Enamel Furnaces. Ferro Corp., 35 pp, ill. Discusses special oven design features and advantages and describes seven basic types of ovens and dryers, their uses and characteristics. (191)

Electric Muffle Furnaces. Harper Electric Furnace Corp., No. 346. Features and specifications of this company's line of electric muffle furnaces for such uses as heating and annealing. (192)

Furnaces. C. I. Hayes Inc., 44 pp, ill, No. 112. Complete data on a variety of furnaces for hardening, tempering, carbonitriding, forge heating, sintering, annealing and tool heat treating, as well as on atmosphere generators and ammonia dissociators. (193)

Induction Heating Generators. Induction Heating Corp., 4 pp, ill. Technical data and case histories with applications of 2½- and 3½-kw induction heating generators. (194)

Heat Treating. James H. Knapp Co., Inc., 8 pp, ill. Description of Knapp-Lee quick drench, heat treat furnaces for aluminum heating. (195)

Surface Hardening Stainless Steels. Lindberg Steel Treating Co., 24 pp, ill. Gives complete data on the Malcomizing process for surface hardening stainless steels. Seven case histories are included. (196)

Induction Heating. The Ohio Crankshaft Co. Describes plant survey and possible applications to which induction heating might be put for greater production economy. (197)

Liquid Carburizing. Park Chemical Co., 4 pp, ill, No. 82. Physical properties and applications of a water soluble liquid carburizing material. (198)

Electric Furnaces. Pereny Equipment Co., 3 pp, ill, No. 4A. Booklet tells advantages and illustrates typical group of this company's furnaces and kilns and their uses. (199)

Stainless Steel Hardening. C. U. Scott & Son Inc., 62 pp, ill. Discusses Super Scottsonizing, a method for hardening precision stainless steel parts after machining. (200)

Vacuum Furnace. F. J. Stokes Machine Co., 4 pp, ill, No. 770. Describes a complete line of vacuum furnaces and their applications to the high vacuum processing of metals. (201)

Furnaces. Surface Combustion Corp., 4 pp, ill, No. SC-162. Presents a complete line of high-speed furnaces for press forging, extruding, upsetting, etc. (202)

Industrial Furnaces. Lee Wilson Contracting Co., 8 pp, ill. Illustrations of more than 14 furnace types for many large scale industrial uses. Gas, oil and electric heat treating furnaces. (203)

Welding • Joining

Hard-Facing Electrodes. Alloy Rods Co., 12 pp, ill, No. AR53-20. Nine basic types of hard-facing electrodes and four basic types of hard-facing rods with photographs illustrating uses. (207)

Silver Brazing. American Platinum Works, 48 pp, ill. Reference manual on silver brazing discusses low temperature brazing, brazing alloys, design considerations and other topics. (208)

Tube Welding. Babcock & Wilcox Co., Tubular Products Div., Technical Data Card No. 155. Reference table designed to help fabricators of tubular materials select welding process for various steel and B&W Croloy combinations. (209)

Glass Joints. Cerro de Pasco Corp., 2 pp. Instruction sheet for making glass-to-glass and glass-to-metal seals with indium and tin solder. (210)

Rivets. Champion Rivet Co., 48 pp. Specifications of small and large rivets and comprehensive tables of approximate weights. (211)

Weldment Assemblies. Continental Foundry and Machine Tool Co., 6 pp, ill. Advantages of large welded assemblies, typical applications, and production facilities available. (212)

Rosin Core Solder. Division Lead Co., 4 pp. Features Divco's X-25 rosin core solder, which provides flux activity at a temperature even before the solder is completely molten. (213)

Fasteners. Elastic Stop Nut Corp. of America, 29 pp, ill. A collection of many fastening problems with solutions. (214)

Welding Alloys. Eutectic Welding Alloys Corp. Three-color wall chart to assist in the selection of the proper welding alloys. (215)

Solder Alloys. Federated Metals Div., 36 pp, ill. Properties of fusible alloys, principles and thermal effects of soldering and applications, descriptions and specifications of this company's solders. (216)

Stainless Steel Welding. General Electric Co., 8 pp, ill, No. GET-1955. Presents a variety of welding and metallurgical applications of stainless steels. (217)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 261 and 262

Constant Voltage Welding. Glenn Co. 4 pp. Answers to 14 basic questions regarding constant voltage power sources for automatic welding. (218)

Silver Brazing Alloys. Handy & Harman, 24 pp, ill, No. 20. Information on Easy-Flo and Sil-Fos low temperature silver brazing alloys, and valuable data on brazing methods. (219)

Stainless Steel Fasteners. H. M. Harper Co., 56 pp, ill. Price list and stock book covering complete line of this firm's nonferrous and stainless steel fastenings. (220)

Induction Heating for Brazing. Lepel High Frequency Laboratories Inc., 8 pp, ill. Details on induction heating units for accelerated brazing of parts. (221)

Weld Strength Calculator. Lukens Steel Co. A slide rule type calculator indicating sizes of weld required for given load and weight of the weld in pounds. (223)

Spot Welding Aluminum Alloys. P. R. Mallory & Co., Inc., 36 pp, ill. Detailed description of spot welding for aluminum alloys, plus specifications and diagrams. (224)

Rivets. Milford Rivet & Machine Co. A handy slide rule selector gives complete rivet specifications. (225)

D. C. Welder. Miller Electrical Mfg. Co., 8 pp, ill. Specifications and accessories for d.c. arc welding units. (226)

Welding Torches. National Welding Equipment Co., 16 pp, ill. Presents the many advantages resulting from using this company's welding torches. (227)

Fastener. New Process Screw Co. Bulletin describes Twin-fast screws for rapid fastening of wood to metals, plastics or other woods. (228)

Stainless Steel Fasteners. Star Stainless Screw Co. Lists Star's stainless and special machine products available. (229)

Cherry Blind Rivets. Townsend Co., 12 pp, ill, No. TS-76. Information on applications, specifications and types of cherry blind rivets and rivet guns. (230)

Brazing Alloys. United Wire & Supply Co., 3 pp, ill. Wire brazing aluminum for low temperature brazing of various metals and alloys. (231)

Welding Positioners. Worthington Corp., Industrial Div., 36 pp, ill, No. 210 C. Description, features and applications of 100- to 40,000-lb capacity welding positioners. (232)

Forming • Casting • Molding Machining

Coated Abrasives. Armour Sandpaper Works, 124 pp, ill. Catalog of complete line of coated abrasives. Includes tables. (237)

Wet-Abrasive Cut-Off Machine. The Cincinnati Electrical Tool Co., 2 pp. Description, features, alternating and direct current specifications of this wet-abrasive cut-off machine. (238)

Injection Molding. Guy P. Harvey & Son Corp., 1 p, ill. Includes specifications of the Vacurator, which offers rapid production of master patterns, formed hollow

MANUFACTURERS' LITERATURE

samples and zinc alloy sample molds. (239)

Semi-Automatic Presses. The Hydraulic Press Mfg. Co., 4 pp, ill, No. 5107. Gives description and specifications of H-P-M automatic compression and molding presses for reinforced plastics molding. (240)

Plastics Molding Equipment. Improved Paper Machinery Corp., 4 pp, ill. Features and advantages of Impco injection-compression, plunger, transfer and injection molding machines for plastics. (241)

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Tabletting Presses. F. J. Stokes Machine Co., 24 pp, ill, No. 800. Illustrates and describes a complete line of Stokes tabletting presses for pharmaceutical, plastics, ceramics, powder metal and general industrial production. (243)

Sheet Metal Fabricator. Wales Strippit Corp., 6 pp, ill, No. 10-a. Gives features and specifications of Hydra-New-Matic head and the "Quick Change" holder. (244)

Aluminum Extrusion Presses. Watson-Stillman Co., ill, No. 340-A. Describes this company's light metals extrusion presses of 500- to 5000-ton capacities, their features and advantages. (245)

Magnetic Perforating Dies. S. B. Whistler & Sons Inc., ill. Complete descriptions and applications of this company's magnetic perforating dies. (246)

Inspection • Testing • Control

Laboratory Reagents. Allied Chemical & Dye Corp., General Chemical Div., 40 Rector St., New York, N. Y., 264 pp, ill. Complete buyer's guide for uses of laboratory reagents and chemicals. Includes such pertinent facts as grades, strength and maximum limits of impurities. Request direct from Allied on company letterhead.

Test Chambers. American Research Co., 4 pp, ill. Describes the basic environmental test chambers produced by this company for testing under a variety of conditions. (250)

Photoelastic Stress Analysis. Eastman Kodak Co., 16 pp, ill, price 35¢. Booklet briefly discusses photoelastic stress analysis as a method of solving problems of stress distribution. (251)

Identification of Some Metals. The International Nickel Co., Inc., 48 pp, ill. Procedures for spot testing of some metals and alloys for identification purposes. (252)

Dew Point Controller. Ipsen Industries Inc., 2 pp, ill, No. C-21. Specification dimensions and applications of dew point controllers of furnace atmospheres. (253)

Temperature Controller. Leeds & Northrup Co., 20 pp, ill, No. ND47. Electronic instruments for two-position or proportional control for temperature and conductivity. (254)

Testing Equipment. Magnetic Analysis Corp., 8 pp, ill, No. 10. Multi-method equipment for nondestructive tests of ferromagnetic bars, rods and tubing. (255)

Surface Roughness. Micrometrical Mfg. Co., 4 pp, ill, No. LT85. Methods for judging surface roughness and use of the profilometer. (256)

Pyrometers. Minneapolis-Honeywell Regulator Co., 48 pp, ill, No. 100-5. A complete line of pyrometer supplies illustrated and described. (257)

Universal Testing Machines. National Forge & Ordnance Co., Testing Machine Div., No. 501. Specifications, capacities and operating principle of table model universal testing machines. (258)

Temperature Control. The Pyrometer Instrument Co., No. 150. Catalog shows Pyro-Immersion Pyrometer, accurate instrument for nonferrous foundry temperature control. (259)

Electronic Metal Detector. Radio Corp. of America, 4 pp, ill, No. E42. Features of electrical metal detector designed for use on conveyors to detect tramp metal. (260)

Ultrasonic Testing. Sperry Products Inc., 8 pp, ill, No. 50-110. Complete data on sonic inspection, measurement and control systems. (261)

Flex-Tester. Steel City Testing Machines Inc., 4 pp, ill. Apparatus for the nondestructive testing of sheet metal drawing qualities and stretcher strain. (262)

Radiography. Technical Operations, Inc. Folder with data sheets. Gamma radiography equipment and methods used with Cobalt 60. (263)

Temperature Indicators. Tempil Corp., 6 pp, ill, No. 53MS. A complete line of crayons, pellets and lacquers for temperature control and heating metals. (264)

Impact Tester. U. S. Testing Co., Inc., 2 pp, ill. Includes history, description and use of the SPI low temperature impact tester. (265)

Process Control. Wheelco Instruments Div., Barber-Colman Co., 42 pp, ill, No. TC-10. Data book and catalog of thermocouples, radiation detectors, resistance bulbs and other accessories for indicating, controlling and recording instruments for use in process control. (266)

General

High Vacuum Applications. Consolidated Vacuum Corp., 16 pp, ill, No. CEC-1801B. Applications, methods, features, operation and performance of the model 24-101A leak detector in accurately detecting and locating leaks in vacuum or pressure equipment. (271)

Product Research. Arthur D. Little Inc., 4 pp, No. A. Description of product research and engineering services. (272)

Materials Controls. Remington Rand Inc., No. KD 367. Booklet describes Kardex system for keeping visible materials and parts inventories coordinated with production. (273)

Metal Processing. Arthur Tickle Engineering Works Inc., 16 pp, ill. Profusely illustrates the facilities of this company for forging and plate fabricating, metal spraying, and Alumibonding and aluminum casting. (274)

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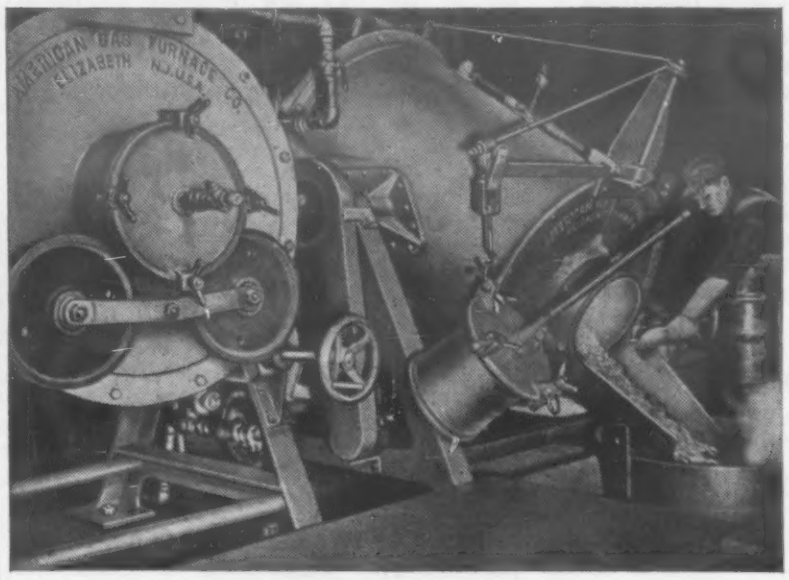

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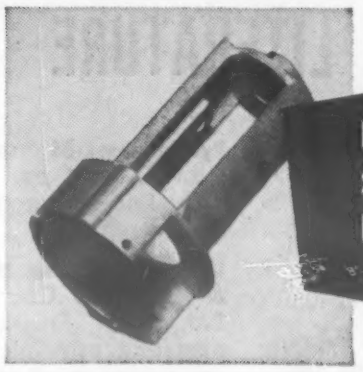

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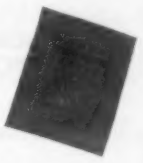

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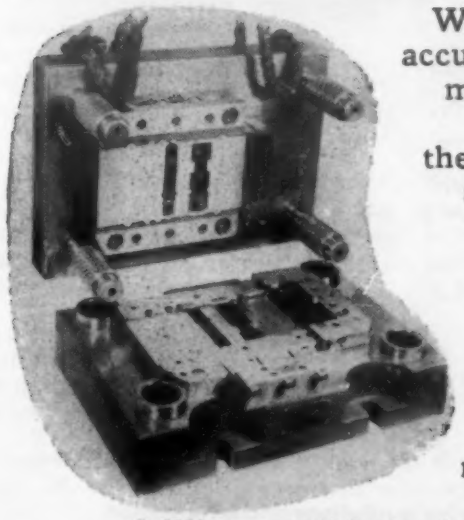

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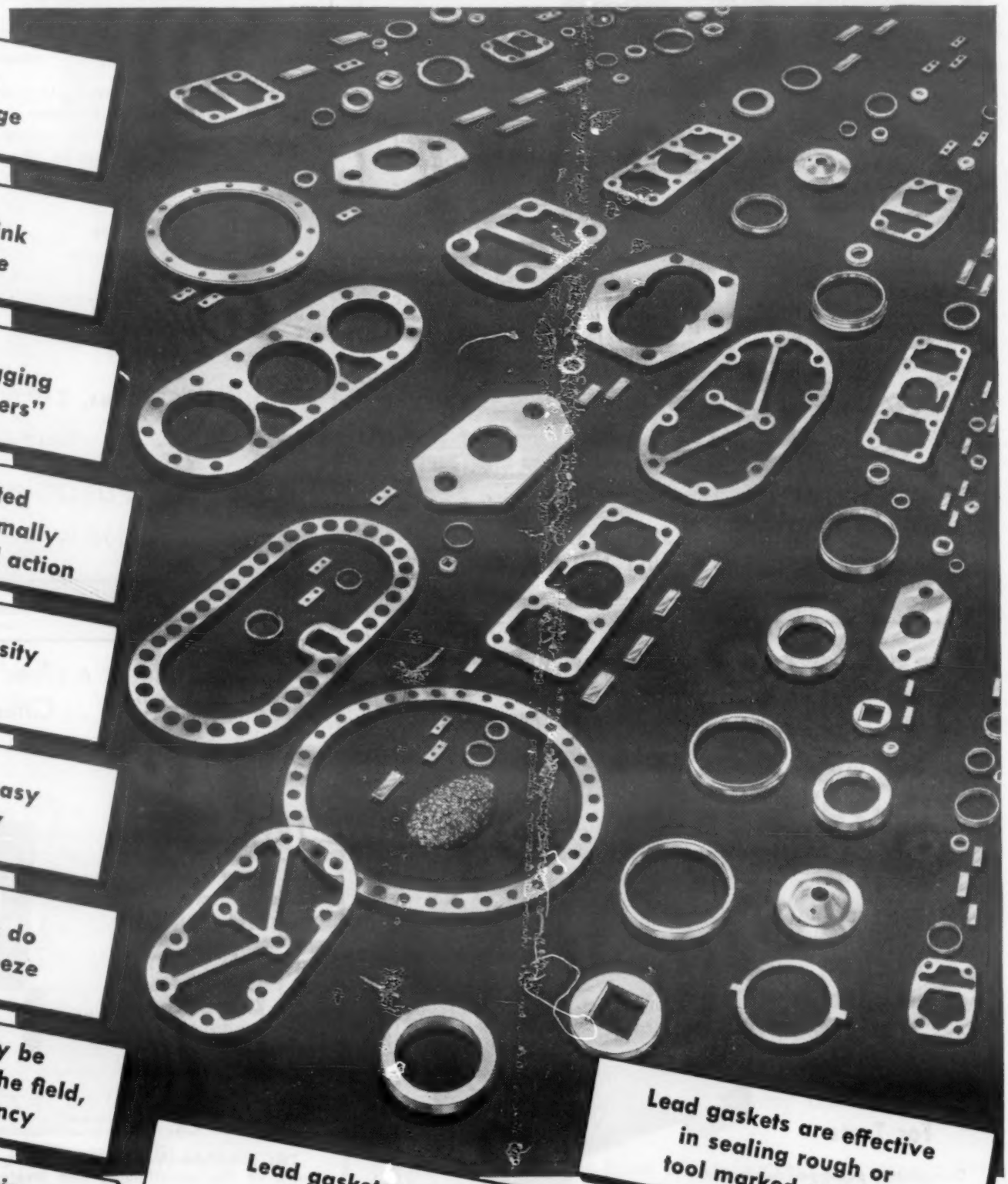

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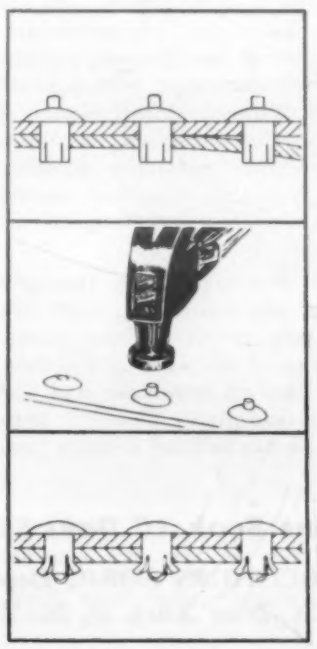

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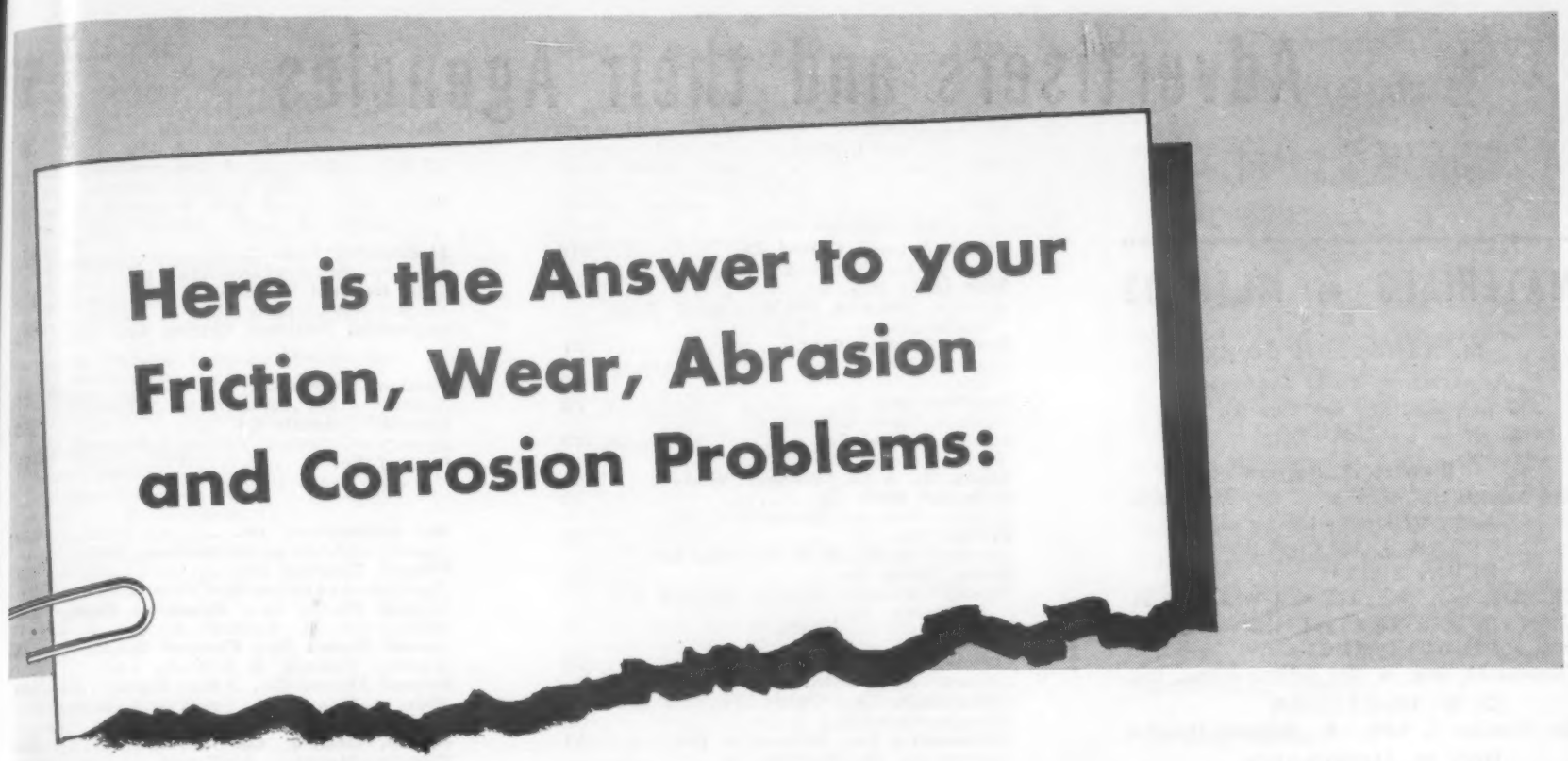

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The Editor's Page

Do-It-Yourself

At the moment it's hard to decide whether the latest development in the do-it-yourself field is to be a boon or a bust. As you must have heard by now, Reynolds is putting out a special alloy for the use of home craftsmen. Biggest selling point is that regular woodworking tools can be used to cut, plane, turn and drill and otherwise machine the metal. And there's the rub! We know that many people will overlook the warning not to try these same tools on regular aluminum alloys. Thus there could soon be a rash of sore heads and broken tools.

A New Twist

If the fashion experts have their way, nickel, long known as "your unseen friend," is soon to come out in the open. Recently the women's page of a New York newspaper showed some new high-fashion shoes which used nickel-silver heels. For artistic effect the heels were twisted into a stylish helix. Try and bust these heels. Could be dangerous weapons in intra-family bridge games.

In the Bag

We knew all along that plastics would soon get us into trouble by poking its ubiquitous nose into many nooks and crannies. At a recent trade show one of the exhibitors passed out cocktails packaged in little plastic bags. In adjacent compartments of the cocktail bags were the vital ingredients plus the cherry or olive so necessary in matters of this kind. Now the well-worn "I'll take a rain check" attempt to avoid taking another drink will be negated. They'll just give you a hand-full of bagged cocktails to protect you against snake bites and cold weather. Whether or not cocktails in this form ever reach the retail market is not now known, but if they ever do, beware!

Have a Seat

Recently we visited the plant of the American Seating Co. in Grand Rapids, Mich. In addition to being amazed at the number of seats in this country that must be provided for, we were amused by a unique testing device employed there. The ingenious tester is called "Squirming Susie" or some such name and simulates to perfection a restless theater-goer. The realistic wooden shape goes through all of the twisting and squirming motions of an over-tired husband who has been dragged out to a grade "C" movie. This is simulated service testing at its best, or worst.

Backward Progress

It has taken the world thousands of years to get out of its caves and underground holes and into modern homes with all of their comforts. However, we are now being advised to go back to that mode of living if we want to survive the ravages of atom and hydrogen bombs. According to some merchants of doom, we have no hopes for the future. If they are right, we have certainly made progress. Just think, television, radar, jet propulsion and caves in just one generation.

Not Like Home

If there is one thing to be learned from countless plant visits it is this: never be surprised at any unusual things you might see. For example, we recently went through the new automated production line of the Curtiss-Wright turbo-compound aircraft engine. There in the midst of all the glistening, complex assembly machines, we discovered a plain old household electric roaster. The device, it was discovered, was ideal for warming parts which were assembled as slip-fits. When the parts cooled from the roasting temperature, they shrunk into place. Mighty clever, these aircraft engineers.

Vocabulary Lesson

Don't look this up in your collegiate dictionary for you probably won't find it. However, an ancient word is now coming back into extensive use. The word is *serendipity*. It is used among researchers to identify a form of luck. According to the best definition, serendipity is an art—the art of finding things you are not looking for, or of making unexpected discoveries. Just so you will know, you must be told that the word was coined by the famous gentleman, writer, and wit—Hugh Walpole. And that is our smattering of culture for today.

T. C. Du Mond
Editor

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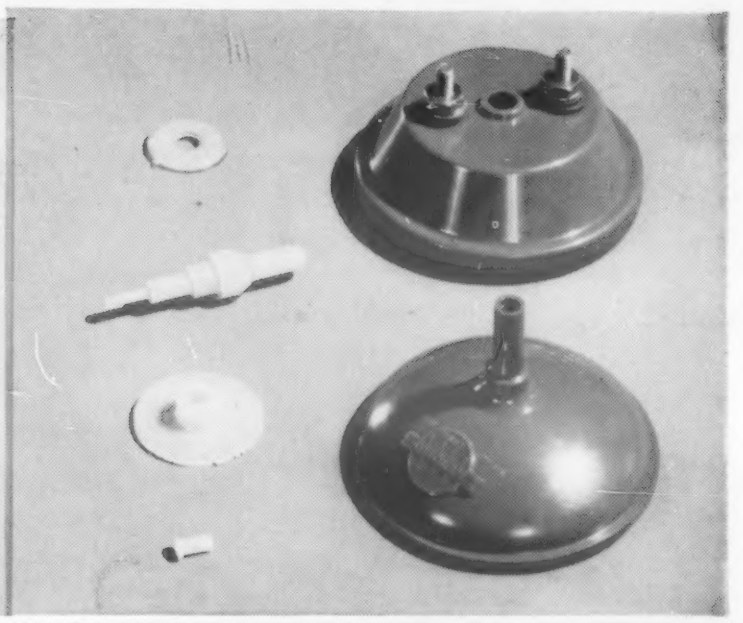

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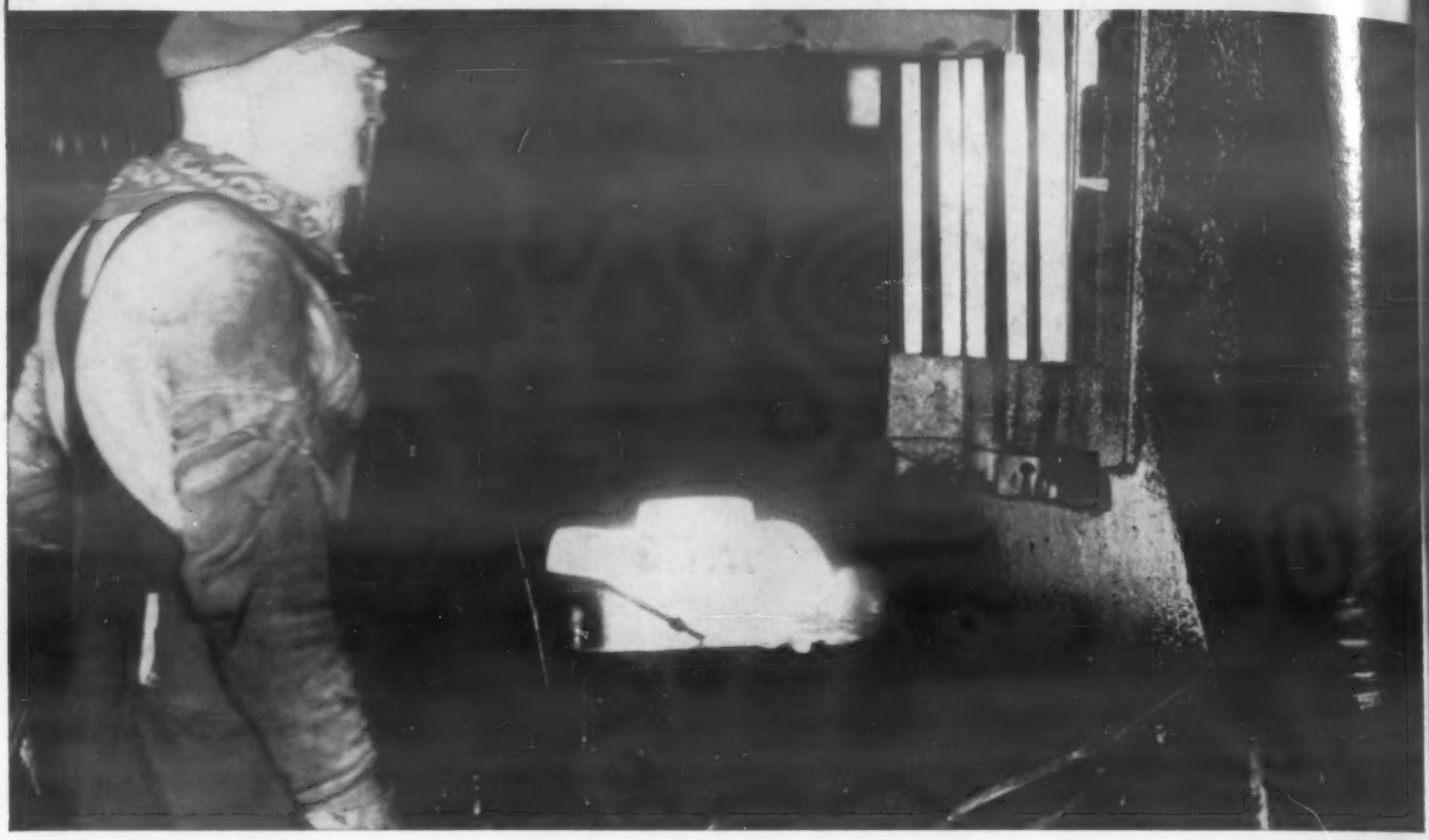

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